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MARYLAND

Agricultural Experiment Station.

BULLETIN, No. 21.

THE SOILS OF MARYLAND.

COLLEGE PARK, MD.

June, 1893.

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Located on the B. & O. R. R., 8 miles N. of Washington, D. C.

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COLLEGE PARK, MARYLAND.

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THE SOILS OF MARYLAND.

By Milton Whitney.

INTRODUCTION.

The object of this report is to show that there are different kinds of soils in Maryland in which the conditions of plant growth are very different, making each best adapted to certain crops and classes of plants. They are not, therefore, equal in agricultural value because they are not all equally adapted to the same crops. It will be shown, also, what the conditions are which give the peculiar and characteristic agricultural value to the different soils and how these conditions may be maintained so as to maintain the fertility of the land or changed so as to increase the yield or improve the quality of the crop.

It was necessary to find out how many different soils there are in the State, and their exact location, and then to study the conditions in these soils and their relation to plant growth.

The study of the Maryland soils was originally undertaken by the Experiment Station, but the subject was so large and the principles to be worked out were of such general and widespread application that the co-operation was sought of the Johns Hopkins University, and afterwards of the Weather Bureau of the United States Department of Agriculture, and this has been very freely and cordially given in both cases. The Johns Hopkins University has continued the use of their estate of Clifton for the investigations with the use of the mansion house for laboratory and office rooms, as well as the free use of their own well equipped laboratories and libraries and the association of their workers. The Weather Bureau has provided means to employ several assistants to enlarge the scope of the work and make a thorough study of the relation of soils to rainfall and heat. At the reorganization of the Experiment Station last year, no provision was made for continuing these soil studies, but they were continued, nevertheless, with the help received from the other institutions; the work was much crippled, however, as two assistants had to go and field work stopped which had already been started in different parts of the State. The work is being resumed by the Experiment Station, but much valuable time and opportunities have been lost.

The work done since my last report to the Experiment Station consists of the collection and examination of a large number of samples of soils from Maryland, and the classification of all the most important for-

mations, exclusive of those on the Eastern Shore; the collection of soil samples from other parts of the country and an examination of some of this material. Mr. F. P. Veitch and Mr. James B. Latimer, graduates of the Maryland Agricultural College, have been with me for a large portion of the time and have done valuable laboratory work in the examination and study of the soils. Mr. H. C. Sherman was here for a time engaged on a special study of some samples of rice soils for the Division of Statistics, United States Department of Agriculture, the results of which have been published in a bulletin on "Rice," recently issued. Prof. J. A. Udden, of Augustana College, Rock Island, Illinois, was here for about three months examining a collection of soil samples from that State, collected by Mr. Frank Leverett and sent to me by direction of Dr. Joshua Lindahl.

Prof. R. L. Packard has been authorized by the Department of Agriculture to make a thorough study of the chemical and petrographical composition of the soils and he has been engaged on this investigation for some months. Part of Prof. Packard's results are ready for publication and they will be noticed here, but much of his work has been a study of methods for the identification of the different minerals in the soil and of the form of combination of the constituents in the soil. Mr. W. J. A. Bliss has been working for several months in the physical laboratory of the University, on a study of the forces acting between solid bodies immersed in a liquid, and the effect of fertilizing materials thereon, which will have an important bearing on the effect of fertilizers on soils. These forces are relatively so small and act at such exceedingly small distances that the investigation requires the most refined methods, and most of the time has been spent in the study of methods suitable for this work. The method seems to be about perfect now, but the utmost refinement is necessary to remove all traces of grease and all particles of dust from the glass surfaces employed.

The study of soils in their relation to crops is obviously more than a mere local question, and should include a study of soils of known agricultural value from widely different localities. The opportunity to collect material for such a study, was presented this year in my connection with the United States Department of Agriculture and in the widespread interest in the collection and exhibit of samples of soils from the different States at the Chicago Exposition. I took advantage of this opportunity to collect a large amount of material, amounting now to 1500 samples, collected from all over the United States, and in most cases carefully identified and described with very full information as to the geological origin of the soils and their agricultural value. This collection includes samples from nearly all of the larger and more important agricultural regions of the United States, as well as the soils best adapted to the different staple crops, collected from the most typical localities.

There are a greater number of geological formations in Maryland than in any other State, and these represent the entire sequence from the

old igneous and crystalline rocks to the most recent quarternary formation. These formations have all been carefully sampled. The collection also includes samples from the grass, corn and wheat regions of the West and Northwest; the prairie soils, glacial drift and loss of Illinois; the blue grass region of Kentucky; a very full collection of the soil formations of Tennessee; the Sea Island and upland cotton soils of the South; the red lands, prairie lands and alkali lands of Colorado and the far West; the gumbo, adobe and mesa soils of New Mexico; samples from the Great Salt Lake Desert; a very full collection of soil samples from Alabama; the drift soils of the New England and Northern States; also soils from the typical tobacco regions of Massachusetts, Connecticut, New York, Pennsylvania, Tennessee, Kentucky, Wisconsin, Virginia, North and South Carolina, and other States. Part of this material has been worked up and will be described in a report to the Department of Agriculture.

Since my last report to the Experiment Station, I have made a report to the Department of Agriculture, which was published as Weather Bureau Bulletin, No. 4. I have also written a number of shorter papers for *Agricultural Science*, the Monthly Report of the Maryland State Weather Service, the *Maryland Farmer*, a Chapter on the Rice soils of South Carolina for a bulletin on Rice from the Division of Statistics, United States Department of Agriculture, and the Chapter on Agriculture for the Maryland book prepared for the World's Fair. All of these were preliminary to this report and to a later one for the Department of Agriculture, and they will be freely used here.

A map has been prepared for the World's Fair book of Maryland, showing the area and location of the principal soils in Maryland, exclusive of those on the Eastern Shore. The Eastern Shore soils have not been studied in sufficient detail to allow of a description and classification of the soils because the geology of that part of the State, upon which this work is based, has not yet been worked out. This map cannot be given here, but a small outline map is given showing the area of the different formations.

THE SOILS OF THE STATE.

The following is a list of the principal soils of the State with the average content of sand, silt and clay, together with the approximate number and the surface area of the grains in one gram.

LIST OF THE PRINCIPAL SOIL FORMATIONS OF MARYLAND.

	Geological Formation.	Description of Soils.	Average Content, Sand, Per Cent.	Average Content, Silt, Per Cent.	Average Content, Clay, Per Cent.	One Gram of Subsoil Contains: Surface area.	One Gram of Subsoil Contains: Approximate number of grains.
1	Lafayette	Pine barrens of Southern Maryland	90	5	3	496	1.692,000,000
2	Columbia	Early truck lands along the west shore of the bay and in Caroline, Wicomico, Somerset and Worcester Counties	80	10	55	673	2.185,000,000
3	Columbia	Later truck and fruit lands along the bay	70	15	10	1,244	4,767,000,000
4	Chesapeake	Tobacco lands of Southern Maryland (export tobacco	45	35	15	1,902	6.786,000,000
5	Chesapeake	Wheat lands of Southern Maryland	55	20	20	2,380	9,357,000,000
6	Columbia	Wheat lands of river terraces along the Potomac and tributaries	20	50	25	2,889	11,936,000,000
7	Chesapeake	Grass and wheat lands of Southern Maryland	30	35	30	3,479	14,457,000,000
8	Chesapeake (?)	Wheat and corn lands of Queen Anne and Talbot Counties (Eastern Shore)	30	40	30	3,479	14,457,000,000
9	Phillite	Wheat and corn lands of Harford, Carroll, Frederick and Montgomery Counties	30	40	30	3,479	14,457,000,000
10	Gneiss	Grass and wheat lands ("Gray lands") of Harford, Baltimore, Carroll, Howard and Montgomery Counties	25	40	30	3,479	14,457,000,000
11	Gabbro	Grass and wheat lands ("Red lands") of Harford and Baltimore Counties	25	40	30	3,479	14,457,000,000
12	Triassic re l sandstone	Grass and wheat lands ("Red lands") of Carroll and Frederick Counties	10	50	35	3,700	14,900,000,000
13	Catskill red sandstone	Grass and wheat lands of Garrett and Alleghany Counties	10	50	35	3,700	14,900,000 000
14	Chesapeake (?)	Wheat lands of Dorchester, Wicomico, Somerset and Worcester Counties	10	50	35	3,700	14,900,000,000
15	Helderberg	Grass and wheat lands of Washington and Alleghany Counties	15	40	40	4,500	19,638,000,000
16	Trenton limestone	Grass and wheat lands of the Cumberland and Frederick Valleys	5	45	45	5,000	22,000,000,000
a	Granite	Similar to gneiss					
b	Serpentine	Bare hills					
c	Cambrian sandstone	Mountain peaches					
d	Hudson River shales	Wheat and fruit					
e	Clinton-Niagara shales	Mountain pasture					
f	Hamilton-Chemung shales						
g	Salina sandstone						
h	Medina sandstone	Mountainous					
i	Oriskany sandstone						
j	Pocono sandstone						
k	Coal measures						
l	Potomac	Bare clay hills					
m	Cretaceous	Fruit and truck lands with 10 per cent. of clay, similar to Columbia (No. 3)					
n	Eocene						

There are a few other formations in the State of very small area or of little or no agricultural value. The soils given in the above list vary, of course, somewhat in texture and in composition, and it will be seen that two or more distinct types of soil may be found in the same geological formation.

Having determined what soils occur in the State, and having outlined the areas of the different soil formations on a map, it remains to study the relation of the soils to plant growth. Upon what does this relation depend? Upon the chemical composition of the soils as shown from a chemical analysis as commonly held by agricultural chemists? This can hardly be, for reasons which will appear.

It is a significant fact that the soils arranged in the above table by *number*, with the exception of No. 14, representing the white clays of the Eastern Shore, are about in the order of their relative agricultural value for such staple crops as grass and wheat, and this value seems to be determined by the percentage of clay, although this is not necessarily so, as we shall see.

The Potomac formation for example, has as much clay as the Trenton limestone, but it has little agricultural value; the grains of sand and clay have not the same arrangement as in the limestone soils, and the soils are compact and impervious to water. The grains in the other soils, designated by numbers, appear to have nearly the same arrangement, and the percentage of clay practically determines their relative agricultural value for staple crops. Another very significant thing is that the percentage of clay represents very nearly the yield of wheat on these lands in bushels per acre, under favorable conditions and with good treatment; and it is still further true that the percentage of clay very nearly represents the present market value of these lands for wheat. Practically the lands are worth, as wheat lands, about $1.00 per acre for every percentage of clay they contain, provided the grains have about the same arrangement as in the soils of the table. We shall see that the percentage of clay largely determines the texture of the soils and their relation to moisture and heat. If these facts just referred to are more than mere coincidences, they show that the agricultural value is largely dependent upon the texture of the soil.

THE RELATION OF THESE SOIL TYPES TO PLANT GROWTH.

This may be conveniently discussed under four heads: (1) the chemical composition of the soils; (2) the effect of climatic conditions on the development and yield of crops; (3) the climatic conditions of Maryland; (4) the relations of the soils to moisture and heat and to the yield of crops.

1. *The Chemical Composition of the Soils.*—Plants, like animals, require food for their life and growth. The greater part of the food of plants comes directly or indirectly from the atmosphere, but a very important part is derived from the soil. Of the mineral matters in the soil the most important for the nourishment and growth of plants is silica,

alumina, iron, lime, magnesia, potash, soda, sulphuric and phosphoric acids. These are contained in the mineral fragments of which the soil is composed, and they are all widely distributed, although contained in variable amounts in different soils depending upon the kind and composition of the minerals of which the soil is composed. Different plants require different quantities of this mineral matter. 100 pounds of pine wood, for example, contain less than ½ pound of these mineral matters derived from the soil, all the rest of the wood being derived directly or indirectly from the atmosphere. The tobacco plant, on the other hand, contains from 15 to 25 pounds of mineral matter derived from the soil in 100 pounds. This is the grossest feeder of any of our agricultural plants. While all plants contain all of the above mineral substances, different classes of plants require different proportions of each. A few years ago it was very generally believed that a comparison of the chemical analysis of a soil and plant would show what was lacking in the soil for a large crop, and that this element could then be supplied in the form of a fertilizer, but no such simple relation as this exists. It has been shown that, as a rule, all soils contain enough of the mineral elements required for plants, in an available form, with the possible exception of lime, potash, phosphoric acid and nitrogen. Soils rarely contain less than 1 ton (0.05 per cent.) each of lime, potash, phosphoric acid and nitrogen in an acre, 12 inches deep, and usually from 2 to 20 tons of each of these plant foods. Very barren soils and soils which have been "worn out and exhausted" have frequently been shown by chemical analysis to contain as much of these plant foods as is contained in the fertile prairie soils. Further, the amount of food material taken up from the soil by a single crop is relatively so small that its loss cannot be detected with any certainty by a subsequent chemical analysis.

Notwithstanding the vast store of plant food in all ordinary soils, applications of fertilizers, containing no more than 15 or 20 pounds of lime, potash, phosphoric acid or nitrogen added to the soil will often make the difference between a large crop and a failure. 20 pounds of any of these plant foods when applied to an acre of land and thoroughly worked in cannot afterwards be detected by the most refined chemical means. Since plants require such a small proportion of the plant food within their reach and yet often respond so readily to relatively very small quantities applied in fertilizers, it is generally believed that only a small part of the mineral substances in the soil is in a form of combination available to plants; the rest of the plant food being in such a form of chemical combination that it is not available for the time to plants. It is believed that this plant food never accumulates to any great extent in the soil in an available form, but if it is not used by plants it quickly reverts to an insoluble and unavailable form of chemical combination.

It has been found that the chemical analysis of soils and plants is no sure guide to the kind of soil best suited to crops or the kind of fertilizer required. Many plants requiring relatively large quantities of phosphoric acid or of potash or of lime seem to be able to gather these ingredients

with comparative ease from the soil and respond more readily to an application of other plant foods of which they contain relatively little in their composition. Other plants on the same soil would respond more readily to an application of phosphoric acid, potash, etc. It is inferred from this that plants differ in their power of gathering food from the soil.

A vast number of field experiments have been carried on in the past fifty years to determine the specific requirements of different classes of plants, and of different kinds of soils. The results of these field experiments are, as a rule, very uncertain and conflicting, and while they are doubtless of value in showing the general needs of a particular field the results cannot be used with safety in the cultivation of the same crop on a different kind of soil or on the same soil in different seasons.

This is a practical problem presented by our Maryland soils. It is as easy to produce 40 bushels of wheat per acre on some of our heavy limestone lands as it is to produce 5 or 10 bushels per acre on some of the light truck lands of Southern Maryland. According to the prevailing ideas of plant nutrition, which have just been given, this would be because the light truck lands are deficient in available food, but we shall see that the indications are that this explanation is not warranted by the facts, and that the difference in the chemical composition of the soils is not sufficient to account for the difference in their agricultural value.

Prof. R. L. Packard was authorized by the United States Department of Agriculture to make a thorough study of the chemical composition of some of the typical Maryland soils to supplement my own work on the physical structure and properties of these soils. Prof. Packard was to inquire into the chemical composition of the soils with special reference to the form of combination of the chemical elements and the identification of the minerals still remaining in the soil as a source of supply of the plant food. Much of Prof. Packard's time has necessarily been taken up with the study of methods of analysis and methods for the separation and identification of the minerals, and these methods are only just now well in hand. The methods and the results of his work will be described at length at another time.

The first thing to do for the identification of the minerals in the soil was to make a bulk analysis of the soils to find out their actual ultimate composition. This would give an idea of what classes of minerals might reasonably be looked for. The table of these results is given here for it will show the whole amount of plant food in the sub-soils of a number of soil types in Maryland having widely different agricultural values.

MECHANICAL ANALYSES OF MARYLAND SUBSOILS (BULK ANALYSES).

BY PROF. R. L. PACKARD.

	Lafayette, barrens.	Columbia, early truck.	Columbia, truck and fruit.	Chesapeake, tobacco.	Chesapeake, wheat.	Columbia, wheat and corn.	Chesapeake, grass and wheat.	Gneiss, grass and wheat.	Gabbro, grass and wheat.	Triassic, grass and wheat.	Helderberg, limestone, grass, whe't.	Trenton, limestone, grass, wheat.	Potomac, barrens.
	209	472	467	258	245	201	247	1045	1025	949	288	933	592
Loss on ignition	1.21	0 94	1.90	5.06	4.16	4.84	6.23	6.37	8 20	7.38	7.27	12.70	5.84
Silica, SiO_2	94.32	95.87	91.37	80.59	85.44	79.66	73.90	68.93	66 27	55.39	66.17	47.24	66.89
Alumina, Al_2O_3	2.66	1.87	5.24	6.64	6.11	13.08	12.96	14.70	15.25	20.16	16.31	26.17	16.50
Iron, Fe_2O_3	1 25	0.50		3.62	2.95		4 71	4 98	6.97	8.79	6.61	7.76	8.77
Phosphoric acid. P_2O_5	0.02	0.03	0.05	0 27	0.18	0 94	0 17	0.03	0.07	0.04	0.03	0.14	0 21
Magnesia. MgO	0.07	0 04	0.12	0.36	0 08	0.32	0.11	0 32	0.43	1.27	0 94	0 38	0.02
Lime, CaO	0 04	0.07	0.09	0.31	0.11	0.23	0.17	0.54	0.24	0 51	0 44	0 18	0.10
Soda, Na_2O	0.11	0.10	0 13	0.38	0.46	0.44	0.33	0.97	0.40	0.79	0.62	0.29	0.49
Potash, K_2O	0.12	0.17	0.39	0.94	0.76	1.09	1.31	1 51	0.86	4.03	1.06	4 41	1.31
	99.80	99.59	99.29	98.17	100.25	99.70	99.89	98.35	98.69	98.36	99.45	99.27	100.13
"Clay," (.005-.0001 *mm.*)	3.74	4.40	10.59	14.55	19.57	25 03	32.40	28.82	34.90	38.63	43.44	51.77	44.51

The soils, as thus arranged, are in the order of their relative agricultural value, except that 247, 1045 and 1025 have nearly the same agricultural value, and 592 represents the barren hills of the Potomac formation having hardly more agricultural value than the sandy pine barrens (209) at the other end of the table.

On the whole, there appears to be a remarkable uniformity in the ultimate composition of these sub-soils, and little to indicate that the increasing agricultural value of the lands is dependent upon the actual amount of plant food in the sub-soils. The phosphoric acid, lime and potash do increase regularly in the first three samples, and seem to show a relation to their agricultural value, but this apparent relation stops here. There is no sudden break in agricultural value between 467 and 258. The latter produces an excellent quality of tobacco, but it is too light in texture for wheat and grass. Not over 10 or 15 bushels of wheat per acre can be produced on this land with the same treatment that would produce 25 or 30 bushels on 247, 1045 or 1025, and yet the chemical analysis shows it to be richer in phosphoric acid and lime than any of the others and richer in potash also than 1045, which is the strongest grass and wheat land of the three. 258 contains more phosphoric acid and lime than the Trenton limestone (933) although not nearly so much potash. 245 is decidedly a stronger soil than 258, and yet it has less of all these important elements of plant foods.

While 1025 (Gabbro) and 1045 (Gneiss) have about the same agricultural value, the former is considered rather stronger and more durable than the latter; but it is here shown by the chemical analysis to have considerably less of these important plant foods, with the exception of phosphoric acid.

The Helderberg limestone (288) is considered the strongest and most durable grass and wheat land represented in the table, with the exception of the Trenton limestone (933), and yet it is lower in all the essential elements of plant food than the gneiss (1045), and hardly differs much in the content of phosphoric acid, lime and potash from the light textured tobacco land of Southern Maryland (258).

The Triassic red sandstone (949) and the Trenton limestone (933) contain very high percentages of potash, but otherwise there is nothing to indicate their high agricultural value. The cause of the high potash content in the limestone land will be referred to later. Both of these lands are benefited by liming, but the former already contains three times as much lime as the other and about as much as any of the soils in the table.

592 represents the strong clays of the Potomac formation which have little agricultural value—yet the analysis shows it has a high content of phosphoric acid and potash, although deficient in lime. In other respects it resembles the Helderberg limestone, although the two soils are as different as can be in agricultural value. The lime content is about the same as in 245, which is a good land wheat, and is not far short of that of the Trenton limestone.

So far as these results go they do not show any close relation between the ultimate composition of the soils and their relative agricultural value. It was Prof. Packard's intention to make an analysis of the acid extract of these soils after the official method, but time has only permitted of four partial analyses being completed in time for this report. The results are given in the accompanying table:

MATERIAL EXTRACTED BY STRONG HYDROCHLORIC ACID FROM THE MARYLAND SUB-SOILS.

By Prof. R. L. Packard.

	Chesapeake Wheat. 245.	Helderberg Limestone 288.	Trenton Limestone. 933.	Potomac Clays. 592.
Alumina, Ae_2O_3	5.54	11.69	20.66	6.21
Iron, Fe_2O_3	2 95	6.61	7.76	8.77
Phosphoric acid, P_2O_5	0.18	0.03	0.14	0.21
Lime, CaO	0.10	0.21	0.12	0.03
Soda, Na_2O	0.81	Lost	0.54	0.04
Potash, K_2O	0.41	Lost	1.14	0.33

In this table the agricultural value of 245 is far less than either of the limestones, and yet the reason for this does not appear from the analysis; while it has less potash than the Trenton limestone (933) it still has a fair amount. Here again no cause can be seen for the low agricultural value of the Potomac clays save in the very low percentage of lime.

To have an idea of the vast store of plant food in soils it will be well to remember that 0.05 per cent. represents about 1 ton per acre to a depth of 12 inches, and most plants go much deeper than this for their food. According to this there is contained in the acid extract, which is usually considered *available plant food*, in 245, 3½ tons of phosphoric acid, 2 tons of lime and no less than 8 tons of "available" potash. In the Trenton limestone there is no less than 24 tons of "available" potash in an acre 12 inches deep, and nearly four times this amount of total potash.

Another matter to be borne in mind in considering the ease with which water and roots can extract this food material for plants is the extremely fine state of sub-division of the soil grains. One gram (15½ grains) of 245 has about 2,200 square centimeters of surface area or no less than 85,000 square feet (2 acres) of surface in 1 cubic foot of soil for water and roots to act on in extracting food material. The Trenton limestone (933) has 5,600 square centimeters of surface in 1 gram, or 158,000 square feet (3.6 acres) of surface in 1 cubic foot. If glass,

which is considered very insoluble in water, is powdered quite fine and boiled in water for several days about one-third part by weight will be dissolved. Most agricultural plants have more than one cubic foot of earth to grow in, and the vast extent of surface area of the soil grains should make it possible for them to collect a large amount of plant food even if it existed in the soil in a comparatively insoluble form.

The cause of the high percentage of potash in the limestone soil has been partially investigated by Prof. Packard, who finds a quantity of a dull, yellow-colored, amorphous-like mineral in the clays, having a high potash content. This mineral is very widely distributed, not only in sample 933, but also in samples from other localities in the Hagerstown Valley. Most of it is so thoroughly disintegrated that it can only be distinguished by its color in the mass of clay, but by working over a large amount of clay under water and washing off the fine material some rather large fragments of the mineral were obtained, which were analyzed with the following results:

CHEMICAL ANALYSIS OF THE MINERAL OCCURING IN THE CLAY SUB-SOIL OF THE TRENTON LIMESTONE FORMATION.

By Prof. R. L. Packard.

Loss on Ignition	2.99
Silica, SiO_2	58.36
Alumina, Al_2O_3	23.88
Iron, Fe_2O_3	trace
Magnesia, MgO	0.32
Lime, CaO	0.11
Soda, Na_2O	1 95
Potash, K_2O	11.72
	99.32

The mineral has not yet been identified, nor has the source or manner of deposition been determined.

This work certainly throws a flood of light upon the composition of the soils and the combination of mineral fragments composing them, but it does not show any close relation between the chemical composition and the increasing agricultural value as shown in the order of their arrangement in the table.

2. *The Effect of Climatic Conditions on the Development and Yield of Crops.*—Boussingault says in his "Rural Economy:"* "The mineral substances which we have now studied, taken isolatedly, would form an almost barren soil; but by mixing them with discretion, a soil would be obtained, presenting all the essential conditions of fertility, which depends, as it would seem, much less upon the chemical constitution of the elements of the soil than on their physical properties, such as their faculty of imbibition, their density, their power of conducting heat, etc. It is unquestionable by studying these various properties that we come to form a precise idea of the causes which secure or exclude the qualities we require in arable soils."

*Law's Edition, Page 214.

We have seen that the difference in the chemical composition of our Maryland soil types is not sufficient to account for the difference in the agricultural value of the lands. It is a matter of experience that even if as much plant food were added to the light truck soils as would be required by a large wheat crop this would not insure a large yield of wheat by any means, so that there must be some other factor besides the mere amount of plant food in the soil which controls the development of the crop on these soils.

We have a number of distinct types of soils in Maryland. These range in texture from the very light, sandy soils of the pine barrens and of the truck lands, to the very heavy limestone soils of Western Maryland. The light sandy soils are so open and porous that water rapidly descends through them after a rain. The heavy limestone soils, on the other hand, are so close in texture and so retentive of moisture that the rainfall passes down through them very slowly. The rainfall does not do the crops any good until it enters the soil. Even assuming, therefore, that we have the same amount and distribution of rainfall over the whole State, the soils are so different in their retentive powers that some will maintain much more of this rainfall for the crop than others.

In this locality, rain falls on an average, about every third day, but as a rule, rains come at no such frequent or regular intervals, for we usually have a fall of rain on two or three consecutive days and then an interval of a week or ten days of dry weather. The soil has to conserve this rainfall for the use of plants during this dry weather period, so that the actual water supply of the plant is dependent upon the soil and the resistance it offers to the descent of the rainfall. The finer the texture of the soil and in general the more clay it contains the greater will be the resistance offered.

For example, a limestone soil containing 45 per cent. of clay, will maintain on an average, from 18 to 22 per cent. of water, or about 400 tons of water per acre one foot deep; the light truck soil, containing 5 per cent. of clay, will maintain only about a quarter of this amount, that is, about 5 or 6 per cent. of moisture, or say 100 tons of water per acre. The limestone soil to a depth of 1 foot maintains an amount corresponding to 4 inches of rainfall, while the light sandy truck land maintains an equivalent of only 1 inch of rainfall. Now the difference in the effect on a crop of a season when there are 4 inches of rainfall a month and when there is only 1 inch of rainfall a month is very great. For if we have an average of 4 inches of well distributed rainfall a month, a good wheat crop is assured on the limestone soils, but if we have an average of only 1 inch of rainfall a month, the crop will be a failure. As a matter of fact we have, on an average, about 4 inches of rainfall a month in Maryland, and this is sufficient for a good wheat crop on the limestone soils; but, as we have seen, the light sandy truck lands are so porous that they let this water down very freely and only maintain for the crop an amount equal to 1 inch of the rainfall.

If there should be as much difference as this in the amount of water supplied to plants in a green house, those plants which received the most water would develop into large leafy plants, which would be late in coming to maturity, while the plants receiving the less amount of water would be smaller, but there would be a greater tendency to fruit and the plants would mature much earlier. This is precisely the effect on the two soils under consideration. When wheat is sown on the sandy truck soil it does not tiller well, but throws up one or two stalks which attain hardly any size before each takes on a seed head and the plant ripens. The conditions have not been favorable for the development of a sufficient amount of foliage to gather enough plant food from the soil and atmosphere for a large crop, but the plant has been forced to maturity before it has attained sufficient size. The crop is large in proportion to the amount of food material which has been gathered by the plant, but there is relatively so little of this that it gives a very small yield per acre. On the heavy limestone soil on the other hand, the crop grows slowly, gets a good root development, tillers well, and produces a mass of foliage which gathers a quantity of food material from the soil and air before it is time to ripen the grain.

In heavy wet soils and in wet seasons plants are inclined to grow very large, and they do not put on as much fruit as they should, considering the size of the plant and the amount of food material that has been gathered from the soil and air. Under these conditions cotton plants, which are extremely sensitive to the wetness of the soil and to the season take on a large and rank growth and produce a small yield. On drier soils and in drier seasons the plants are smaller and yield larger crops. Wheat also shows this, although to a less extent than cotton. Under these same conditions tobacco plants are large and rank, the leaves are coarse and sappy and do not cure well or take on good color. In drier seasons and on drier soils the leaves have a finer texture and a brighter color. On the light sandy soils the conditions, as a rule, are unfavorable to wheat and grass, but these drier conditions are distinctly favorable for forcing crops to an early development, and this is what gives them their great value for early truck. By forcing these vegetables to an early maturity the vegetables are put on the market two or three weeks earlier than they can be produced on the heavier soils of the State, and they bring a higher price; the same crop grown on a heavier and more moist limestone soil would be so late in coming to maturity that it would have to compete with all other parts of the State, and there would likely be a glut in the market and the crop would bring a very low price. We thus see that the character of the season and the soil has much to do (1) with the total yield of the crop, as with the cotton and wheat crop; (2) with the quality of the crop, as with tobacco; (3) with the time of ripening, as with the truck and vegetables.

In a green-house a florist may use the same kind of soil, but he must maintain very different conditions of temperature, and especially of moisture, for the different kinds of plants and according to the way he

wishes the plants to develop. If he desires the plant to make a large root development he gives it bottom heat; if he desires it to make a stalky, leafy development he puts it up near the glass and keeps the atmosphere warm and the soil moist. A geranium plant can thus be kept from blooming and developed to a large size as a foliage plant with a great number of leaves by keeping the soil moderately warm and moist. By maintaining these conditions of a high temperature and of a moist soil he can prevent any tendency of the plant to flower or ripen fruit, or he may simply retard the blooming of the plant until such time as he desires it to blossom. If it is desired to have the plant bloom and flower profusely the soil must be kept drier and cooler; this checks the excessive growth of foliage and the plant is induced to blossom and ripen fruit. Thus the development of the plant is under nearly perfect control, and it is very customary for florists and gardeners to force their plants to any kind of development by the simple control of moisture and heat; to make large and leafy plants of them or to keep them smaller by checking this excessive growth of foliage and make them put all their substance into a profusion of flowers and fruit.

Our different soils, being very different in texture and in their relation to moisture and heat, partake somewhat of these artificial conditions of green-house culture, and they are each best adapted to different crops or to different kinds of development.

In the deterioration of these lands the texture of the soil changes so much that it has a very different appearance to the eye, and a soil which is "worn out" or "exhausted" can generally be very quickly detected by a simple inspection. The development of the crop is also very different, indicating that the relation of the soil to moisture and the amount of of moisture it can maintain for the crop has been changed.

Fertilizers have a very marked effect on the texture of soils, as some fertilizers, such as lime with organic matter for example, will make the soil much more retentive of moisture, while others, as for example, lime alone will make the soils looser and more loamy and less retentive of moisture. This physical action of fertilizers in changing the texture of soils and their power of supplying water to crops is probably much more important than their value as mere plant foods.

It seems, therefore, that if the physical conditions of moisture and heat are favorable to the proper development of crops, that plants can, in general, get all the food they need from nearly all soils; that these conditions may change with any change in the texture of the soils, and that the development of the plants and the yield of crops will thereby be affected favorably, or otherwise; that we have in our common manures and fertilizers very powerful and potent means of maintaining or of changing the texture of the soils and thereby changing the conditions of moisture and heat which they can maintain for the crop, and that it is through this physical effect of manures and fertilizers, in controlling the supply of moisture and heat within the soil, under existing climatic

conditions, that the chief value of fertilizers and manures lies, rather than in the relatively small amount of plant food which they add to the soil.

According to this, the reason wheat cannot be as successfully grown on our light truck soils as on our heavier limestone soils of Western Maryland is not because of any deficiency of available plant food in the truck soils, but because the conditions in the light soils are not favorable to the kind of development required to make a large wheat crop. To thoroughly understand and appreciate the effect of the different conditions of temperature and moisture maintained by these different soils by reason of their difference in texture, it will be well to give here a summary of some of the most important data showing the effect of the ordinary climatic conditions on the development and yield of crops. As a basis for comparison it will be well also to show the effect of the application of ordinary commercial fertilizers.

The Rothamsted experiments serve to illustrate this point very well. The following table gives the yield of wheat per acre for a long period of years with different fertilizers:*

AVERAGE YIELD PER ACRE OF WHEAT BY DIFFERENT MANURES FOR 32 YEARS (1852-83) ON BROADBALK FIELD, ROTHAMSTED.

	Yield.	Increase Per Cent.
Unmanured	13⅛	...
Mineral manures alone	15¼	16
Ammonia salts alone (86 pounds nitrogen)	20⅞	59
Mineral manures and ammonia salts (86 pounds nitrogen)	32¾	149

It will be seen from this table that the continuous application of the mixed manures and ammonia salts increased the yield of wheat from 13⅛ bushels per acre to 32¾ bushels, over a period of 32 years, an increase of 149 per cent. over the yield from the unmanured land. This may certainly be considered a very handsome increase, and any farmer would be well satisfied to increase his crop of wheat from 13⅛ bushels per acre to 32¾ bushels per acre and to hold it at this figure.

*The Rothamsted experiments, Fream, page 57.

The following table gives the yield of wheat per acre in the best season, 1863, and in the worse season, 1879.*

THE YIELD OF WHEAT PER ACRE IN THE BEST SEASON, 1863, THE WORSE SEASON, 1879, AND THE AVERAGE OF 32 YEARS, 1852-83.

	1863.	1879.	Difference.		Average 1852-83.
			Bushels.	Per Cent.	
Unmanured	17¼	4¾	12½	265	13⅛
Mineral manures alone	19⅝	5⅝	14	249	15¼
Mineral manures and 200 pounds ammonia salts	39⅝	10½	29⅛	277	24⅛
Mineral manures and 400 pounds ammonia salts	53⅝	16¼	37⅜	230	32¾
Mineral manures and 550 pounds nitrate soda	55⅝	22	33⅝	152	36¼
Mineral manures and 600 pounds ammonia salts	55¾	20⅝	35⅛	170	36¼
Farm yard manure	44	16	28	175	32½

In 1879 the yield was 4¾ bushels per acre on the unmanured plot, while in 1863 the yield on the same plot, with presumably the same treatment, was 17¼ bushels, an increase of 12½ bushels, equal to 265 per cent. of the lower yield, due apparently to climatic conditions. The yield in 1879, where the mineral manures and 200 pounds of ammonia salts had been applied, was 10½ bushels per acre; in 1863, under the same treatment, the yield was 39⅝ bushels per acre, an increase of 29⅛ bushels, equal to 277 per cent. of the lower yield. In 1879 the yield where mineral manures and nitrate of soda had been used was 22 bushels per acre; in 1863 the yield was no less than 55⅝ bushels per acre, a difference of 32⅝ bushels, equal to 152 per cent. of the actual yield in 1879.

The effect of climatic conditions can be seen even more clearly in the variations in yield from year to year of any single plot. The following table gives the yield from plot 5 with mineral manure alone for a period of 20 years, from 1863 to 1883.†

*The Rothamsted Experiments, Fream, Page 25.
†Ibid, Page 33.

DRESSED GRAIN IN BUSHELS PER ACRE.

YEAR.	Plot 5 Minerals Alone.
1863	19⅝
1864	16⅞
1865	14¼
1866	13¼
1867	9¼
1868	17⅝
1869	15¾
1870	18⅞
1871	11⅞
1872	12¾
1873	12¾
1874	13
1875	9¼
1876	10½
1877	11⅝
1878	14¾
1879	5⅝
1880	17¾
1881	12¾
1882	12½
1883	15¾

In 1879, with the usual application of mineral manures, there was a yield of only 5⅝ bushels of wheat per acre; the following year, with the same treatment, the yield was 17¾ bushels per acre, an increase of 12⅛ bushels, equal to 216 per cent. of the yield in 1879. In other years the yield varied considerably from the effect of the *difference in climatic conditions.*

It is difficult to give in a summary of this kind an idea of the climatic conditions which prevailed during these seasons to have influenced the yield of wheat. It is stated in a general way that any defect in the climatic conditions of England for the production of large and well-matured wheat crops is more connected with an excess of rain and constant wetness of the soil and humidity of the atmosphere than with any deficiency of average summer temperature.*

The following table gives the average monthly mean temperature, the rainfall and the number of rainy days in several seasons which have been remarkable in their effect upon the wheat crops. The wheat season, be it understood, is from October to September.†

SUMMARY OF TEMPERATURE AND OF RAINFALL.

	A.	B.	C.	Average.
Average monthly mean temperature..	49.7	49.8	47.2	48.6
Annual rainfall (inches)	21.44	19.53	32.89	25.4
Number of days on which 0.01 inches or more of rainfall	140	136	199	141

*The Rothamsted Experiments, Fream, Page 71.
† Ibid, Page 70.

A. Is a mean of 6 years of high production of both grain and straw (1832-34-35-54-63 and 64).

B. Four years of high produce of grain, but not of straw, (1833-57-68 and 70).

C. Four years of very low produce (1816-53-60 and 79).

The average mean temperature is of 108 years, 1771-1878. The average rainfall is of 63 years, 1815-1877; average number of days is of 55 years, 1815-1869. These periods were notable in their way for the effect of the climatic conditions upon crop production. This summary gives a general idea of the difference in the seasons, but it must be remembered that it is not only the total heat and total rainfall of a season which should command attention, but the distribution of temperature and of rainfall over the different periods of the season are equally important factors.

The lesson we shall draw from this is that if we had two soils in adjoining fields so different in texture and in their relation to moisture and heat as to maintain conditions of moisture and heat as different as existed in the seasons of 1879 and 1880, then we might expect that in one and the same year the yield from the two soils would be as different as the yields given in the table, and if the light soil yielded 5⅝ bushels per acre the clay would yield something like 17¾ bushels per acre. We shall see presently that our extreme types of soils showing the most markedly different agricultural values are so different in texture that the conditions of moisture and temperature within them are undoubtedly greater than were the climatic conditions in 1879 and in 1880.

The effect of the season on the production of hay per acre is very strikingly shown in the following table:*

THE AVERAGE YIELD OF HAY PER ACRE FOR TWENTY YEARS; YIELD IN 1879, THE YEAR OF HIGHEST PRODUCTIVENESS; YIELD IN 1870, YEAR OF LOWEST PRODUCTIVENESS.

	Plot 3. Unmanured.	Plot 7. Mineral Manure alone.	Plot 9. Mineral Manure and 400 lb. Ammonia salts.	Plot 11. Mineral Manure and 800 lb. Ammonia salts.	Plot 14. Mineral Manure and Nitrate of Soda.	Means.
	lb.	lb.	lb.	lb.	lb.	lb.
Average, 20 years, 1856-75	2,383	3,958	5,711	6,726	6,407	5,037
1869	4,256	6,124	7,700	8,610	8,526	7,043
.......................1870	644	1,968	3,306	5,150	6,300	3,474
+or—average...... 1869	+1,873	+2,166	+1,989	+1,884	+2,119	+2,006
+or—average...... 1870	—1,739	—1,990	—2,405	—1,576	—107	—1,563
1870 less than.. 1869	—3.612	—4,156	—4,394	—3.460	—2.226	—3,569

* The Rothamsted Experiments, Fream, Page 211.

It was estimated that the wheat crop of Great Britain in 1879, on account of the unfavorable conditions, was not more than half the average one.*

Let us turn now to the results of experiments in our own country, and select from a large mass of data a few examples for illustration. The following table gives an idea of the climatic conditions in several of the important agricultural regions of the United States.†

METEOROLOGICAL DATA FOR A NUMBER OF PLACES IN DIFFERENT SECTIONS OF THE COUNTRY FOR A PERIOD OF YEARS.

FROM THE SIGNAL SERVICE RECORDS.

	Winter.	Spring.	Summer.	Autumn.	Year.
Mean Temperature.					
Mass., N. Y., Pa	28.4	45.2	69.9	52.1	48.9
S. C., Ga., Ala., Miss	48.1	63.6	79.9	64.4	63.7
Ohio, Ill., Ind., Iowa	29.0	49.8	72.9	53.4	51.3
Mich., Minn., Wis	20.5	40.6	66.0	47.2	43.6
Mean Rainfall (inches.)					
Mass., N. Y., Pa	9.48	9.21	10.06	11.05	39.80
S C., Ga., Ala., Miss	14.73	15.35	15.32	11.39	56.79
Ohio, Ill., Ind., Iowa	7.80	9.93	12.28	9.48	39.53
Mich., Minn., Wis	6.08	7.55	10.58	9.14	33.62
Mean Dew Point.					
Mass., N. Y., Pa	19	38	58	44	39
S. C., Ga., Ala., Miss	34	51	70	55	52
Ohio, Ill., Ind., Iowa	17	39	60	43	41
Mich., Minn., Wis	12	34	57	40	36
Mean Relative Humidity.					
Mass., N. Y., Pa	75	68	69	72	71
S. C., Ga., Ala., Miss	71	66	72	73	71
Ohio, Ill., Ind., Iowa	73	65	68	70	69
Mich., Minn., Wis	76	69	72	74	73

Average Yield Per Acre of Indian Corn and Wheat—10th census.

	Corn.	Wheat.
Massachusetts, New York, Pennsylvania	32.85	15.19
South Carolina, Georgia, Alabama, Mississippi	11.03	5.77
Ohio, Illinois, Indiana, Iowa	35.79	15 52
Michigan, Minnesota, Wisconsin	34.27	14.52

It will be seen that the mean annual temperature in the four Southern States is 14.8° higher than in the New England States. In the winter it is about 20° higher, in the spring 17.4°, in the summer 10° and in the

*The Rothamsted Experiments. Fream, Page 27.
†Second Annual Report of South Carolina Experiment Stations, 1889, Page 82.

autumn 12.3°. There is a difference of 16.99 inches in the annual rainfall, equal to about 43 per cent. of the mean rainfall, in the New England States. There is a difference in the winter of 5.25, in the spring of 6.4, in the summer of 4.26, and in the autumn of 0.34 inches. The difference in the rainfall is equally important, as it has a greater effect on the crop than the temperature. Plants can adapt themselves more readily to wide differences in temperature than they can to differences in rainfall and moisture, as seen in the very general distribution of wheat and other plants throughout the world.

The average yield of wheat for the three New England States in 1889 was 15.19 bushels per acre, and of Indian corn 32.85 bushels per acre. In the four Southern States the average yield of wheat was 5.77 bushels per acre, and of Indian corn 11.03 bushels per acre. This difference in the yield of wheat and corn is more largely dependent upon the difference in climatic conditions than upon any other factor. The higher temperature and more abundant rainfall and more moist atmosphere at the South, promotes the growth of large crops of straw, but there is little tendency to grain production. Still further South these differences increase, and in real tropical countries there is a very rank growth of vegetation with naturally small grain production. The plant attains very large and full growth and gathers a large amount of food material from the soil and air. Where the growth of the plant is properly checked, by natural or artificial means, and the plant induced to ripen fruit, very large grain crops can be produced and very large crops have been produced, notably, two crops of corn in South Carolina exceeding 200 bushels per acre, which have beaten the world's records. Enormous crops of grass have also been reported from the South.

The difference in the climatic conditions between these different regions has undoubtedly a very marked effect upon crop production and upon the development and distribution of crops, but it will be shown that the conditions of moisture within the different types of soils in Maryland are even greater than the difference in climatic conditions given in the table.

The Effect of Fertilizers on the Yield of Crops. The largest average increase of crop, attributed to any of the different forms of fertilizers in five series of plat experiments extending over a period of five years, at the Indiana Experiment Station, was 6.4 bushels of wheat per acre, which is equal to about 24 per cent. of the yield (26 bushels), where no fertilizer has been used.*

The yield of wheat on unmanured plots at the Kentucky Experiment Station,† was 20.9, 20.2, and 24.2 bushels per acre; the highest yield under fertilization was 29 bushels, an increase over the average of the unmanured plots of about 8 bushels, which is equal to about 40 per cent. of the average yield on the unmanured plots.

*Experiment Station record, November, 1892.
†Kentucky Experiment Station, Bulletin 42, Page 43.

The yield of corn at the North Carolina Experiment Station† on unmanured plots was 2,100, 2,340 and 2,680 pounds per acre. The highest yield where fertilizers were used was 3,140 pounds, an increase of 770 pounds over the average of the unmanured plots, equal to 32 per cent. of the latter yield.

These figures will serve to illustrate the results which are being obtained from the fertilizer tests in our Experiment Station work. It will be remembered that the yield of wheat per acre at Rothamsted was increased, by continuous manuring, from 13⅛ bushels per acre to about 36¼ bushels, an increase of 23⅛, or 149 per cent. of the unmanured plot, over a period of 32 years.

The Effect of the Season on the Yield of Crops. At the South Carolina College‡ seven varieties of cotton were planted for three consecutive seasons. The average yields of all the varieties was 1,229, 1,665 and 1,345, pounds respectively, for the three different years. The greatest difference, of 436 pounds, is equal to 35 per cent. of the lowest yield. The lowest yield of any single variety was 923 pounds in 1883. The following year, with the same treatment, this same variety yielded 1,870 pounds, the increase of 947 pounds due apparently to different climatic conditions, being greater (102 per cent.), than the actual yield in 1883. The difference in the climatic conditions more than doubled the crop.

At the Kentucky Experiment Station§ the average yield of wheat is given for three years of 10 plots which had been differently manured. The average yield in 1887 was 16.9 bushels per acre, and 130 pounds of straw per bushel. The following year the average yield under this same treatment was 25.7 bushels (an increase of 8.8 bushels), and 99 pounds of straw per bushel of wheat. In 1889 the average yield was 23 bushels of wheat and 123 pounds of straw per bushel. The yields on the unmanured plots in 1888 and 1889 were, without exception, greater than from any of the fertilized plots in 1887. Again, the Kentucky Station reports the average yield of 11 varieties of wheat in 1890 at 20.9 bushels per acre; in 1891, with presumably the same treatment, the yield was 27.7 bushels. This increase of 6.8 bushels per acre, apparently due to the difference in climatic conditions, is equal to about 32 per cent. of the yield in 1890. The greatest difference in yield of any single variety in the four years' experiments was equal to about 90 per cent. of the minimum yield.

At the Illinois Station|| a crop of wheat in 1890 yielded 17.5 bushels per acre. In the following year, with exactly the same treatment, the yield was 74.8 bushels per acre, an increase of 57.3 bushels, equal to 328 per cent. of the yield in 1890. The average yield for seven different plots, which had been seeded with different quantities of seed, per acre is given for four years. In 1890 the average yield was 23.9 bushels per

†North Carolina Experiment Station, Bulletin 65, Page 43.
‡Bulletin No. 1, April 1, 1886, South Carolina College.
§Bulletin No. 21, Kentucky Experiment Station.
||Bulletin No. 19, Illinois Experiment Station, Page 35.

acre; in 1891 the yield was 67.7 bushels. This increase of 43.8 bushels, apparently due to the difference in climatic conditions, was equal to about 200 per cent. of the actual yield in 1890, and was about the same as the actual yield in 1889. In the same report is the following table showing the yield per acre of oats for three years with the relative rank of each:

Variety.	Bushels of Wheat.			Relative Rank.		
	1889.	1890.	1891.	1889.	1890.	1891.
New Dakota gray........	41.3	39.4	85.0	17	7	1
Pringles process..........	40.0	48.1	79.0	20	3	2
Early Dakota............	51.3	48 8	63.7	2	2	23
Giant yellow French.....	53.8	34.4	69.2	1	17	15
Welcome	42.6	38.0	68.4	12	8	17
Texas rust proof..........	30.0	55.9	72.2	30	1	8
Improved American......	50.3	25.5	75.2	3	29	5

This is interesting not only as showing the remarkable difference in the yield of oats in the three seasons, but as showing the difference in the relative rank of each. For instance, in 1889 the Giant yellow French had the first rank, with the yield of 53.8 bushels per acre. In the following year this had fallen to 17 in rank; apparently having been effected more than the average by the change in climatic conditions. In 1889 the Texas rust proof oat had the thirtieth place in relative rank, with 30 bushels per acre. In the following year it yielded 55.9 bushels, having risen to the first place in rank; in 1891 the yield was 72.2 bushels, an increase of 42.2 bushels per acre over the yield in 1889, apparently due to climatic conditions.

The average yield of cotton on two unfertilized plots at the Georgia Experiment Station* in 1891 was 204 pounds; in 1890 these same plots, under the same treatment, yielded 672 pounds. This difference of 468 pounds, apparently due to climatic conditions, was equal to about 230 per cent. of the actual yield in 1891.

At the Kentucky Experiment Station† the lowest average yield of nine varieties of oats during four years was 16.4 bushels per acre in 1890. The average yield of these same varieties in 1891 was 40.5 bushels. The difference of 24.9 bushels, due apparently to climatic conditions, is equal to 147 per cent. of the yield in 1890. The greatest difference between the largest and smallest yield for any single variety in the four years was equal to 258 per cent. of the smallest yield.

The lowest average yield of 16 varieties of wheat, over a period of six years at the Ohio Experiment Station,‡ was 28 bushels per acre in 1888. The largest average yield was 45 bushels in 1886; the difference of 17

*Georgia Experiment Station, Bulletin No. 16.
†Experiment Station Record, November, 1892.
‡Bulletin 42, Ohio Experiment Station, August, 1892, Page 97.

bushels is equal to 63 per cent. of the yield in 1888. The largest yield of any single variety was 61.2 bushels per acre in 1886, and the lowest yield of this same variety was 17.5 bushels in 1888, the difference, 43.7 bushels per acre, being equal to 250 per cent. of the yield in 1888.

These figures show the great effect of climatic conditions upon the development and yield of crops. The effect of the differences in the climatic conditions is certainly very much greater than the effect of the application of fertilizers to the crop. Not only is the effect of fertilizers themselves very largely dependent upon the season, as is very generally recognized, but even under the very best conditions and with long continued applications of the fertilizer, the effect of the fertilizer is not so great as the differences in the climatic conditions of different seasons of not at all exceptional characters appear to show.

It would be impossible in a summary of this kind to show the actual changes in climatic conditions which has caused the notable differences in the crop yields which have been reported, even if the data for such a study were at hand.

THE CLIMATIC CONDITIONS OF MARYLAND.

Maryland is divided physically and agriculturally, as well as socially, industrially and politically, into four main divisions, known as the Eastern Shore, Southern Maryland, Northern Central Maryland and Western Maryland, although in many respects the two latter divisions may be classed as one. The agricultural features of these divisions are very different, depending both upon the climatic conditions and upon the distribution of soils. No one can doubt that the difference in climatic conditions has a very marked effect upon the character of the crops grown in these several localities; in the development and quality of the crops grown as well as in the time of ripening. The crops of Southern Maryland are practically all harvested before the corresponding crops of Western Maryland mature. The peach crop of Southern Maryland is practically over before the mountain peaches of Western Maryland come into the market, so that there is little or no competition in the two localities, but a lengthening of the season, as the mountain peaches ripen several weeks later than the lowland crop. The mountain peaches, also, are very different from the lowland crop in appearance, form, color, texture and flavor; in fact, in nearly all of those properties which go to make up the quality of the peach. Similar effects of the difference in climatic conditions is seen in the quality, yield and time of ripening of most of the staple crops grown in these different sections.

The following table gives the acreage and average yield of wheat per acre in the different counties of Maryland, compiled from the 10th and 11th census. The conditions of 1879 were more favorable to a comparison of the yields per acre than in 1889, and the counties are arranged in order of their productiveness per acre in that year, accordingly.

ACREAGE AND AVERAGE YIELD OF WHEAT PER ACRE.—10TH AND 11TH CENSUS.

	1879. Acres.	1889. Acres.	Percent. Dif. 1889.	1879. Bus.	1889. Bus.	Dif. Bushels.
Southern Maryland.						
Charles	15.012	8,579	—42.9	7.1	9.6	+2.5
Calvert	6,581	3,527	—46.4	7.6	7.0	—0.6
St. Mary's	18,554	12,444	—32.9	8.3	10.7	+2.4
Anne Arundel	10.854	6,2[illegible]7	—42.5	9.0	10.9	+1.9
Prince George	14,181	8,250	—41.8	9.0	8.9	—0.1
Average	....	....	—41.3	8.2	9.4	+1.2
Eastern Shore.						
Worcester	5.821	3,661	—37.1	7.1	9.6	+2.5
Wicomico	3,720	2.008	—46.0	7.2	10 2	+3.0
Dorchester	25,979	16,952	—35.1	7 6	12.3	+5.3
Caroline	18 336	19,617	+6.5	10 2	14.8	+4 6
Somerset	8,082	6 050	—25.1	10 3	14 7	+4.4
Queen Anne	41,223	49,313	+19.6	13 5	16.9	+3.4
Talbot	33.129	33 289	+0.4	14.1	19.9	+5.8
Kent	37.581	33,754	—10 1	14.8	17.2	+2.4
Average	....	....	—15.8	10.6	14.4	+3.9
Northern and Western Maryland.						
Alleghany	7,549	5,086	—32.6	8.9	11.7	+2.8
Garrett	4,122	2,562	—37.8	10.7	11.8	+1 1
Baltimore	28 629	26.369	—7.8	13.7	17 4	+3.7
Carroll	40,077	44,704	+11 5	14 4	17.7	+3.3
Cecil	29,875	28.312	—5 2	15 7	19.1	+3.4
Howard	18.445	17,628	—4 4	16 5	17 1	+0.6
Harford	25,143	20,071	—20.1	16.7	18.1	+1.4
Montgomery	35,673	30.237	—14 9	16.9	15.8	—1.1
Frederick	83,767	76 429	—8.7	16.9	16 1	—0.8
Washington	56,923	55,648	—2.2	18.0	17.5	—0.5
Average	....	....	—12.2	14 8	16.2	+1.3

It will be seen that the average yield of wheat in Southern Maryland in 1879 was 8.2 bushels, on the Eastern Shore 10.6, and in Northern and Western Maryland 14.8 bushels per acre. These differences are partly due to the differences in climatic conditions, but they are principally due, as we shall see, to the difference in the soils of the different localities and in the relation of these soils to plant growth. The difference between the 7.1 bushels of wheat per acre in Charles county, and the average yield of 18 bushels per acre in Washington county, is not due to poor farming in the former region, but to the light character of the prevailing soils. The prevailing soils of Southern Maryland are light, sandy or loam soils, while in Washington county there are the strong limestone lands. It will be shown that the amount of moisture in these different types of soil is much greater even than the difference in the rainfall between the Northern and Southern States, as given in a preceding table, and it will appear that this difference in the texture of these soils and in their relation to moisture and heat and the difference in the amount of moisture they are able to maintain for the crop, is amply sufficient to account for the difference in yield shown in this table between the several parts of the State.

In the monthly report of the Maryland State Weather Service* for May, 1893, Prof. Clark has given a carefully prepared summary of the principal climatic features of Maryland, from which the following table of the mean temperature and the mean precipitation is taken:

*Vol. 3, No. 1, Pages 1-6.

MEAN TEMPERATURE.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
STATE.	32.8	34.8	39.6	51.7	62.6	72.5	75.8	74.3	66.9	54.7	44.0	35.5	53.8
Eastern Maryland	34.8	36.1	40.5	52.6	62.1	72.8	75.8	74.8	67.5	56.5	45.3	37.3	54.5
Southern Maryland	35.3	37.4	42.3	53.4	63.9	74.1	77.7	75.7	68.6	56.6	46.5	37.6	55.6
Northern-Central Maryland	30.7	33.9	38.2	50.9	63.5	72.8	75 7	72.4	65.8	54.2	42.8	34.0	53.0
Western Maryland	30.5	31.6	37.2	49.8	60.7	70.3	73.8	74.2	65.8	51.4	41.2	33.0	52.0

MEAN PRECIPITATION IN INCHES (INCLUDING RAIN AND SNOW).

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
STATE.	3.31	3.07	3.92	3.75	4.21	3.72	4.11	3.77	3.67	2.75	3.22	2.69	42.43
Eastern Maryland	3.51	3.22	4.06	4.04	4.29	3.18	4.78	3.78	3.39	3.04	2.70	2.67	42.66
Southern Maryland	3.20	3.51	4.20	4.11	4.40	3.70	4.42	3.84	3.80	2.86	4.11	2.60	44.75
Northern-Central Maryland	3.50	3 10	4.39	3.62	4.06	3.48	4.45	3.98	4.03	2.74	3.25	3.13	43.73
Western Maryland	3.01	2.45	3.02	3.23	4.08	4.53	2.77	3.48	3.46	2.35	2.82	2.35	38.55

SEASONS.

	MEAN TEMPERATURE.				PRECIPITATION.			
	Spring.	Summer.	Autumn.	Winter.	Spring.	Summer.	Autumn.	Winter.
STATE.	51.2	74.0	55.0	34.4	12.88	11.60	9.64	9.31
Eastern Maryland	51.7	74.5	55.8	36.1	12.39	11.74	9.13	9.40
Southern Maryland	53.1	75.5	57.2	36.9	12.71	11.96	10.77	9.31
Northern-Central Maryland	50.6	73.5	54.3	33.1	12.07	11.91	10.02	9.73
Western Maryland	49.4	72.7	52.7	31.7	10.33	10.78	8.63	8.81

The mean temperature is lowest in Western Maryland and is highest in Southern Maryland, as would be expected from the elevated and mountainous character of the former region. The difference in the mean temperature of these two divisions of the State is 3.6°, although there is a difference of about 8° in the mean annual temperature of a place in the extreme Northwestern part of the State and of a place in the extreme Southern part of the State. Comparing the mean temperature of the different seasons, there is a difference of about 3.7° in the spring, 2.8° in the summer, 4.5° in the autumn and 5.2° in the winter temperatures, being higher, of course, in Southern Maryland. The difference is greater than this in places located in the extreme Northwestern part of the State and in the extreme Southern part, amounting to about 12°, 8°, 10° and 13°, respectively, for the different seasons. There is a difference of about 6.25 inches in rainfall between the Western and Southern divisions of the State, which is equal to about one-seventh of the annual precipitation in

Southern Maryland. This difference of 3.6° in the mean temperature and of 6.25 inches of rainfall (about 0.5 inches a month) has, undoubtedly, an important effect upon the agricultural features of the State, but it is not as great, as we shall see, as the difference in the conditions of moisture and heat maintained by the prevailing soils in the two localities by reason of their texture, and it has not so much influence on the development, yield and distribution of crops as the soil influences have.

4.—THE RELATION OF SOILS TO MOISTURE AND HEAT AND TO THE YIELD OF CROPS.

We have seen what a great effect climatic conditions have upon the yield of crops, both when different localities are considered and in the same locality during different seasons. A difference in the temperature, and especially in the amount of rainfall, has a very marked effect upon the development of plants and upon the yield, quality or time of ripening of the crops. Our different soil formations differ greatly in their texture, that is, in the relative amount of sand, clay and organic matter they contain and in the way these materials are arranged in the soils, and they differ, consequently, in the amount of moisture and heat they can maintain for the crops, which has an effect upon the development of plants similar to the effect of the ordinary climatic conditions which have been noticed. It is important, then, not only to study the ordinary climatic conditions of a locality, but to extend this study to conditions in the soil and to find out what becomes of the rain after it falls to the ground, for it does the crops no good until it enters the soil, so that the immediate water supply is dependent upon the power of the soil to conserve this water and to supply it to plants as required. The whole art of cultivation has no other end but to control the water supply in the soil, but obviously, if the soils differ in their power of retaining moisture and of supplying it to crops, this will effect the development of plants and will determine, in part, what kind of cultivation should be given.

Having classified the soils of Maryland, it was expected this year that we would be able to determine the relation of the different soil types to moisture and heat. The Weather Bureau furnished a number of soil thermometers, of a new pattern, made especially for this work, and these were to be put out in the different soil formations. We had arranged, also, to determine every day how much moisture there was in the different soils at the disposal of the crops. This work had already been started in several of the soil formations, and arrangements had been made to have it started in others, but this had to be given up when the Experiment Station dropped the soil investigations at the beginning of the fiscal year. This important work still remains to be done, to determine the actual conditions of moisture and heat in these different soils to confirm our laboratory results, and this work will be taken up whenever circumstances will permit.

It may be well to refer to work which has been done elsewhere to show how different these conditions of moisture and heat may be in dif-

ferent soils. At the North Carolina Experiment Station* the temperature of the soil of the Experiment Farm, on which cotton was growing, was compared with the temperature of some of the fine bright tobacco land in Granville county. The soil of the Experiment Farm was a loam, and that of the tobacco land was "a very fine and compact gray sand." The temperatures were compared on July 28, during a spell of quite warm dry weather, so dry, in fact, that the tobacco was being injured. The mean temperature for the day, calculated from three readings taken at 7 A. M., 1 P. M. and 7 P. M., showed that the mean temperature of the sandy tobacco soil, from a depth of 3 inches to 12 inches, was about 4.5° cooler than the corresponding depth of the loam soil. At a depth of 3 inches the difference in the mean temperature was 5°. At mid-day the temperature of the sandy soil, 3 inches deep, was nearly 10° cooler than the loam soil, although the highest temperature of the surface of the two soils was practically the same. The amount of moisture from 0-6 inches and from 6-12 inches in depth was 6.7 per cent. and 6.71 per cent., respectively, in the sandy tobacco soil, and 6.92 per cent. and 10.78 per cent. in the loam soil at the Experiment Farm, giving a difference of 0.87 per cent. and 4.07 per cent., with a greater difference lower down.

There is also reported the temperature of the upland cotton soil of the Experiment Farm and of a meadow land which was constantly moist. At mid-day the mean weekly temperature of the meadow 3 inches below the surface averaged from 6° to 8° cooler than the same depth in the cotton soil. No moisture determinations were made in these soils. Moisture determinations were made in a loam soil of the Experiment Farm and in a stiff red clay in part of the same field; both soils were under cultivation in cotton. Moisture determinations were made on May 13, June 4 and July 30. The average amount of moisture found in the loam soil from the surface down to 6 inches deep was 13.84 per cent., from 6-12 inches deep, 13.50 per cent. In the clay soil there was 19.24 and 20.41, respectively, in these depths. At a depth of 3 inches the clay soil was uniformly warmer than the loam soil at mid-day, the mean weekly difference from August 6 to November 26 being 2.1°, and the greatest weekly difference being about 5°. Similar results were again obtained over a period of about a month. The clay at mid-day was found to be 4° or 5° warmer than the loam at a depth of 3 inches, and nearly 3° warmer at a depth of 6 inches; 7.71 per cent. of moisture was found in the loam soil at a depth of 0-6 inches, and 17.67 per cent. in the red clay at the same depth; from 6-12 inches there was 11.88 per cent. in the loam and 24.60 per cent. in the clay. Another time it was found that the mean temperature at 1 P. M. of a heavy loam, inclined to a red clay, at a depth of 3 inches over a period of 17 days, was 3.4° warmer than at the corresponding depth in the loam soil. In commenting on these results, the air-dry weight of an acre of these dry soils is assumed to be 1,800,000 pounds to a depth of 6 inches. On April 29 both the clay and

*Annual Report, North Carolina Experiment Station, 1886, Page 93.

loam soil were about saturated from continuous rains, as 18.34 per cent. of moisture was found in the first 6 inches of loam. This was succeeded by very high winds, and one week later (May 5) the loam soil contained only 7.71 per cent. of moisture and was rather dry, while the clay soil contained 17.67 per cent. of moisture. At this time there was 236,000 pounds more moisture in the first 6 inches of the acre of clay than in the loam, from the excess of evaporation or drainage from the loam over the clay.

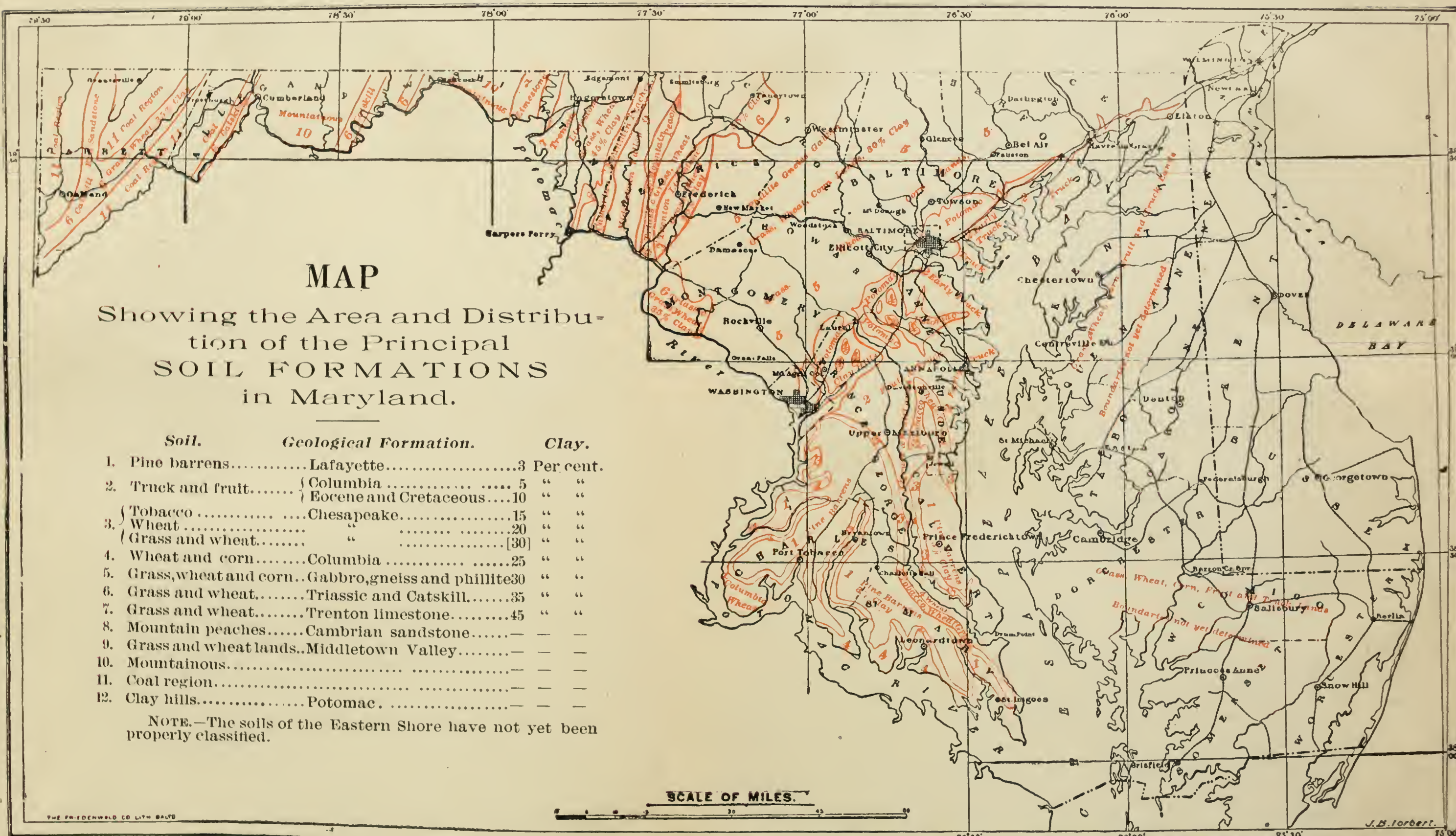
On July 16, 10.55 per cent. of moisture was found in the cotton field, while only 4.91 per cent. of moisture was found on some adjoining land which had been prepared for cotton, but which had been allowed to grow up in crab grass.

In another series of observations on the temperature of loam and red clay at the Experiment Farm, it was found that the clay was much warmer at a depth of 3 inches than the loam, the difference at 1 P. M. frequently amounting to from 5° to 7°, while the temperature of the air 6 inches above the surface of the ground was considerably cooler over the red clay than over the loam soil, the difference frequently amounting to over 5°. The difference in temperature between the loam cotton soil and a similar soil kept constantly saturated with water, was as much as 30° and over for the surface at 1 P. M. At a depth of 3 inches the dry soil was frequently from 8° to 12° warmer than the wet soil.

Comparing thus indirectly the temperature of the light sandy tobacco land, which was about 10° cooler than the loam soil, with the temperature of the stiff red clay, which was shown at another time to be frequently 6° or 7° warmer than the loam, it may be inferred that the difference in temperature at mid-day between the light sandy soil and the stiff red clay would amount to as much as 15° or 20°, the sandy soil being cooler than the red clay. It would likewise appear that the clay soil would contain, on an average, at least two or three times as much water as the sandy soil. The conditions in the sandy soil being very much cooler and very much drier than the clay soil, as we have seen, would have a great effect upon the yield, quality and time of ripening of the crop.

These differences in the conditions of moisture and heat in these different types of soil are far greater than the differences in climatic conditions reported above, and it is to be expected that they would effect the development, yield and time of ripening of crops.

The Relation of the Maryland Soil Types to Moisture and Heat. We have in Maryland much wider and more distinct types of soils than those just referred to in the North Carolina experiments, and the relation of the soils to heat and moisture will show just as wide differences. The sandy soils of the truck lands will be found to be from 15° to 20° cooler in temperature at mid-day than the heavy limestone soils of Western Maryland which are adapted to grass and wheat, and we have already shown that the truck soils can mantain on an average not more than from 4 to 6 per cent. of moisture, while the limestone soils with the



MAP

Showing the Area and Distribution of the Principal SOIL FORMATIONS in Maryland.

	Soil.	*Geological Formation.*	*Clay.*
1.	Pine barrens	Lafayette	3 Per cent.
2.	Truck and fruit	Columbia	5 " "
		Eocene and Cretaceous	10 " "
3.	Tobacco	Chesapeake	15 " "
	Wheat	"	20 " "
	Grass and wheat	"	[30] " "
4.	Wheat and corn	Columbia	25 " "
5.	Grass, wheat and corn	Gabbro, gneiss and phillite	30 " "
6.	Grass and wheat	Triassic and Catskill	35 " "
7.	Grass and wheat	Trenton limestone	45 " "
8.	Mountain peaches	Cambrian sandstone	— — —
9.	Grass and wheat lands	Middletown Valley	— — —
10.	Mountainous		— — —
11.	Coal region		— — —
12.	Clay hills	Potomac	— — —

NOTE.—The soils of the Eastern Shore have not yet been properly classified.


75°00'
38° 30'
38° 00'
rbert.
75°00'

same amount of rainfall would maintain from 18 to 22 per cent. These conditions must be carefully determined for each of our soil types, for it is these conditions which practically control the amount of crop produced and the relation of the different soils to crops, and these conditions are to a large extent under our control through cultivation and through the effect of fertilizers on the texture of the soils.

DESCRIPTION OF THE PRINCIPAL SOIL FORMATIONS OF MARYLAND.

A list of the soils of the State with the average content of sand, silt and clay has already been given. The distribution of the principal soils is shown on the accompanying map. The principles which govern the relation of these soils to crop production have also been given, and it remains now to describe the soils themselves. The following soils have been studied in considerable detail and will be described here:

	SOIL.	GEOLOGICAL FORMATION.	CLAY PER CENT.
1	Pine barrens	Lafayette	3
2	Truck and fruit	Columbia	5
		Eocene and cretaceous	10
3	Tobacco	Chesapeake	15
	Wheat	Chesapeake	20
	Grass and wheat	Chesapeake	30
4	Wheat and corn	Columbia	25
5	Grass, wheat and corn	Gabbro, gneiss and phillite	30
6	Grass and wheat	Triassic and Catskill sandstones	35
7	Grass and wheat	Trenton limestone	45
8	Barren clay hills	Potomac	50

The texture of the soils is found from the mechanical analysis, which consists of separating the different grades of gravel, sand, silt and clay, and weighing each portion and calculating out the percentage of the whole sample. From these percentages it is possible by a mathematical formula* to calculate the approximate number of grains of sand, silt and clay in each group in a given quantity of soil, and to calculate the extent of their surface area. Then by passing air or water through any given depth of soil and noting the time required for a measured quantity to pass, it is possible to show how these grains are arranged in the soil. The number of grains and their arrangement will show how much the space within the soil has been divided up and how much resistance will be offered to the rain when it falls. The organic matter of the soil has much to do with this, but this must be neglected here, and this may be the more readily done as the amount of organic matter in the Maryland subsoils is sensibly constant. The surface area of the grains will show how much surface there is exposed in the soil for the water and roots to act on in dissolving food material.

The following table gives the mechanical analyses of the subsoils of some typical lands of Maryland, with the crops adapted to each.

*This formula is given in Weather Bureau Bulletin, No. 4.

MECHANICAL ANALYSES OF SOME TYPICAL MARYLAND SUBSOILS.

Diameter.	CONVENTIONAL NAMES.	Early truck, Marley. 472	Truck and small fruit. 467	Peas, tomatoes, cabbage, wheat 478	Wheat and grass. 480	Limestone, grass and wheat. 173
mm.						
2-1	Fine gravel	0.49	0.76	2.05	0.00	0.54
1-.5	Coarse sand	4.96	8.55	3.31	0.38	0.32
.5-.25	Medium sand	40.19	35.04	5.41	1.07	0.72
.25-.1	Fine sand	27.59	19.26	2.89	0.78	0 62
.1-.05	Very fine sand	12.10	8.42	6.06	3.41	4.03
.05-.01	Silt	7.74	11.38	40.15	43.08	36.02
.01-.005	Fine silt	2.32	4.13	13.14	13.81	14.99
.005-.0001	Clay	4.40	10.59	23.84	30.21	41.24
	Total mineral matters	99.70	98.13	96.85	92.80	98.48
	Organic matter, water, loss	0.30	1.87	3.15	7.20	1.52

NO.	SOIL.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
472	Early truck, Marley	4.40	615	1,950,000,000
467	Truck and small fruit	10.59	1,244	4,767,000,000
478	Peas, tomatoes, cabbage, wheat	23.84	2,242	10,923,000,000
480	Wheat and grass land	30.21	3,242	14,457,000,000
173	Limestone, grass and wheat land	41.24	4,575	19,638,000,000

472 is a typical sandy truck land from Marley. The crop matures on this land from one to three weeks earlier than on the other soils of the table, and while the yield per acre is not as large the crop brings a very much higher market price. 467 is well suited to truck and fruit but it is not as early as the last sample. Crops mature about a week later on it but it yields more per acre. 478 is still heavier in texture than the sample just described. It is too heavy for sweet potatoes and canteloupes, and these crops cannot be successfully grown. It is too heavy for early truck. Tomatoes, corn, cabbage and peas do well on this land and yield good crops, but they do not ripen as early as on the lighter soils. 480 is a strong clay wheat and grass land on a ridge near where the last sample was secured. 173 is a strong red clay from the limestone region of another part of the State. This represents nearly the strongest and most fertile agricultural land in the State.

The strong clay soils (480 and 173) are not lacking in any particular plant food required by a crop of sweet potatoes or of canteloupes, yet these crops cannot be successfully grown on them. They contain all the elements of plant food needed by a crop of tomatoes, but the tomato vines would be large and bushy—they would be late in maturing and the yield would be small in proportion to the size of the plants. All kinds of truck would be late in coming to maturity. These are sure signs that

the soils have retained too much of the rainfall for the best and earliest development of these crops. The conditions are favorable to grass and wheat for both of these crops require a long and slow period of growth so that they can put on a large amount of foliage before it is time to ripen a crop.

The light truck lands, on the contrary, will not grow a large crop of grass or wheat because the conditions are not favorable to the slow growth required by these plants to produce foliage to gather food material from the soil and air, for the crop is forced to maturity before it has attained any size. With good treatment the light truck land (472) would not bring over 4 or 5 bushels of wheat per acre; 467 would yield from 5 to 10 bushels; 478 would yield from 18 to 20 bushels; 480 would yield from 25 to 30 bushels and 173 would yield from 30 to 40 bushels.

Fertilizers must be used on all these soils to maintain their fertility, and under ordinary treatment about the same amount is used for all the soils, and yet it is seen from the chemical analyses that the clay lands have rather more plant food, and from the mechanical analyses that the mineral particles in the clay lands have from four to six times as much surface area for the food material to be extracted from.

The productiveness of these lands increases with the amount of clay they contain and with the number of grains of sand and clay per gram. These are the conditions which determine the relation of the soils to water and the amount of moisture they maintain. The light textured soils contain, on an average, 5 or 6 per cent. of moisture and are cooler, while the heavy clay soils contain 18 or 20 per cent. It cannot be doubted that the peculiar adaptation of these soils to the different kinds of crops is due to the texture of the land and to the relation of the soils to water; and it is probable that the most important effect of fertilizers is their physical effect in changing the relation of the soils to moisture, rather than to the amount of plant food they add to the soils. It follows, of course, from this that if the physical conditions of moisture and heat are favorable to the proper development of crops, that plants can, in general, get all the food they need from these Maryland soils and the application of fertilizers must be used to this end to regulate these physical properties rather than to supply food to the crops.

The following is a description of the principal soils of Maryland:

1. **Pine Barrens,** *Lafayette formation.* These sandy lands cover an extensive area in southern Maryland. The subsoil contains only about 3 per cent. of clay. It has approximately 1,600,000,000 grains of sand and clay in one gram. These grains have about 496 square centimeters of surface for water to act on in dissolving food material and for roots to feed on. A cubic foot of soil will have about 23,940 square feet of surface area.

The grains are so large and there are relatively so few of them in this soil that the lands are coarse and sandy, and are so little retentive of moisture that they are not able to maintain over 3 or 4 per cent. of moisture, which is too little for any agricultural crop. At present these lands have little value for agricultural crops and are left out as pine bar-

rens. They would make the very earliest truck lands, however, as crops would be forced to a very early maturity, and with the intense system of cultivation which prevails in truck farming and when this part of the State is opened up and good transportation facilities are offered these will probably be the most valuable lands in the State for early truck. Many of these lands also would bring a very fine grade of tobacco for flue-curing, the quality of which would probably more than counterbalance the small yield per acre.

The following is the mechanical analyses of some subsoils from the pine barrens:

MECHANICAL ANALYSES OF SUBSOILS FROM PINE BARRENS.

Diameter.	CONVENTIONAL NAMES.	Near Baltimore.	Cove Point. 209	Type Sample. 276
mm.				
2-1	Fine gravel	4.03*	0.51	4.87†
.1-.5	Coarse sand	20.88	1.32	9.15
.5-.25	Medium sand	41.11	17.84	38.37
.25-.1	Fine sand	14.25	55.82	33.28
.1-.05	Very fine sand	3.58	16.75	3.52
.05-.01	Silt	2.64	3.08	3.47
.01-.005	Fine silt	1.61	0 90	1.55
.005-.0001	Clay	3.69	3.74	3.75
	Total mineral matters	91.79	99.96	97.96
	Organic matter, water, loss	8 21	0.04	2.04

NO.	SOIL.	Clay. Per cent.	Surface arrea. Square centimeters.	Approximate number of grains per gram.
......	Near Baltimore	3.69	499	1,780,000,000
209	Cove Point, near Drum Point	3.74	496	1,692,000,000
276	Type sample	3.75	496	1.692.000,000

*Including 2.11 per cent. larger than 2 mm.
†Including 1.81 per cent. larger than 2 mm.

2. **Early Truck and Fruit Lands,** *Columbia, Eocene and Cretaceous formations.* The light sandy lands of the Columbia formation, forming the river necks along the west shore of the Bay and covering extensive areas on the Eastern Shore, are admirably adapted to early truck. They have from 4 to 10 per cent. of clay in the subsoil. The lands are so light in texture that they will only maintain, on an average, about 5 or 6 per cent. of moisture for the crop, when the heavier soils in the western part of the State would have from 18 to 22 per cent. These lands are altogether too light in texture for wheat, and with good treatment they would not bring over 5 bushels of wheat per acre. They are admirably adapted, however, to early truck and this industry has recently grown to very large

proportions. The drier conditions of the soil force the crop to an early maturity, and vegetables ripen on these truck lands at least two or three weeks earlier than on any other of the soils of the State and they consequently bring a good price.

These lands were formerly considered among the poorest agricultural lands in the State, and even now they have little value for general agricultural purposes when they are too remote from quick and easy transportation to enable truck to be grown on them; as a consequence, large areas of these lands are lying idle awaiting improved transportation facilities. Many of these idle lands have about the same texture as the bright tobacco lands of North Carolina, and they will probably raise a fine grade of tobacco for flue-curing.

The Eocene and Cretaceous formations are rather heavier in texture than the Columbia, containing from 8 to 15 per cent. of clay, and are better adapted to fruit than early truck as the crops do not ripen so early and consequently do not bring such good prices.

The lighter soils are more valuable for early truck because they force the crops to an early maturity and they bring a good market price, while the heavier soils are better adapted to fruit. Tomatoes, cabbage, and many other vegetables, do better on the heavier lands and yield more per acre than on the lighter soils, but the crops are not so early and consequently do not bring so good a price. Tomatoes, for example, ripen at least a week earlier in a soil where there is only 5 per cent. of clay in the subsoil than they do on land having 8 per cent. of clay, and this difference in time of marketing the crop materially increases the value, as the earlier the crop is matured the less competition there will be from other parts of the State and the better price it will bring in the market. Every effort is made to have the early truck mature at the earliest possible moment, and no reasonable expense is spared to attain this end. The whole value of these truck lands lies in the possibility of producing these vegetables earlier than they can be produced elsewhere in the State, so that the value of these lands does not depend so much upon the amount of crop they will produce per acre as upon the time the crop matures. Two or three days difference in the marketing of a crop in this trucking business may make the difference between a brilliant success and a failure.

It appears from our investigations that soils containing over 10 per cent. of clay in the subsoil cannot compete for the very early markets unless they are so situated as to be nearly surrounded by water to insure an early planting season and freedom from late frosts. Soils having from 8 to 12 per cent. of clay in the subsoil are better adapted to fruit than the lighter truck soils.

The whole business of truck farming is comparatively new, having existed as a separate industry since 1860, but it has grown to enormous proportions. The following, compiled from the Eleventh Census for the Hand-book of Maryland, shows the wonderful growth of this trucking interest in theState.

The value of market garden products sold in 1879 was given at $873,968, over 60 per cent. of which came from Baltimore county and

probably represents market gardening proper as distinguished from truck farming. In 1889 the value of the products of truck farming for the Baltimore district, *exclusive of market gardening*, was $3,784,696. Part of this came from Virginia and West Virginia, but by far the larger part came from Maryland. This is exclusive of the Eastern Shore, for $2,413,-648 is the value placed upon the crop on the peninsula comprising Delaware and the Eastern Shore counties of Maryland and Virginia. The value of the products of truck farming, exclusive of market gardening, peaches, and small fruits, for Maryland alone, must have been at least $4,000,000, although 1889 was an unfavorable season for these crops. The total value of the wheat crop in the State in 1889 was estimated by the statistician of the U. S. Department of Agriculture, at $4,998,124, and of the corn crop at $6,495,031, so that the value of the truck compares favorably with either of these staple crops, and with market gardening and fruit it would far exceed these other crops, and it is constantly and steadily increasing.

This truck required not over 50,000 acres, but it is estimated that over 500,000 acres were required for the wheat crop, and even more than this for the corn crop. The average value of the truck lands, as given in the Census, is about $98 per acre, while the average value of the wheat and corn lands of the State can hardly exceed $20 or $30 per acre, if, indeed, it approaches these figures. The distinction between market gardening and truck farming in the Eleventh Census is very instructive:

"The production of fruits and vegetables for market has always been prosecuted with great success, in early days as a branch of general farming, and more recently as a specialty known as market gardening. The business is usually carried on with a few highly-enriched and thoroughly-cultivated acres of ground and a rotation of crops, so grown that there may be a daily supply throughout a considerable portion of the year. The farms are usually within a reasonable driving distance of cities and towns, and the products are generally sold to the retailers, and in many cases, especially in the larger towns, directly to the consumers.

"Truck farming, although it also consists in the production of green vegetables for market, is distinguished from market gardening by the fact that, while the market gardener lives near a market and delivers his products with his own teams, usually producing a general variety of vegetables, the truck farmer lives remote from market, is dependent upon transportation companies and commission men for the delivery and sale of his products, and usually devotes himself to such specialties as are best suited to soil and climate.

"Of the vegetables grown by the truck farmers the leading classes are as follows: Watermelons, cabbage, peas, asparagus, melons other than watermelons, sweet potatoes, tomatoes, spinach, Irish potatoes, celery and string beans, ranking in acreage in the order named; beets, cucumbers, cauliflower, carrots, egg-plants, kale, lettuce, lima beans, parsnips, radishes, rhubarb, squashes, sweet corn and turnips are also grown as truck-farm crops, but only to a limited extent as compared to the first named. These, and other vegetables not here mentioned, being grown mostly by market gardeners than by truck farmers."

The following table gives the acreage and the net income per acre of the leading classes of vegetables on truck farms in the Baltimore and peninsula districts. This does not take into account the vegetables grown in market gardens near local markets, nor where the crop is grown in large quantities, as field crops, as is frequently the case with potatoes:

NUMBER OF ACRES AND NET INCOME PER ACRE ON LEADING VARIETIES OF VEGETABLES. ELEVENTH CENSUS, BULLETIN NO. 41.

BALTIMORE DISTRICT	Acres.	Dollars.	PENINSULA DISTRICT.	Acres.	Dollars.
Peas	5,170	29.50	Sweet Potatoes	4,860	48.60
Cabbage	4,165	96 50	Cabbage	3,275	95.00
Tomatoes	3,780	34.00	Peas	3,224	26 00
Sweet Potatoes	3,150	52.10	Asparagus	2,640	84.00
Irish Potatoes	2,860	68.50	Watermelons	2 469	43.00
Asparagus	2,270	87.75	Spinach	2 128	32.60
Spinach	1,980	37.60	Irish Potatoes	1,295	77.25
Watermelons	620	42.00	String Beans	615	32.00
String Beans	585	28.70	Kale	590	50.00
Cucumbers	360	27.50	Tomatoes	416	43.00
Kale	261	47.00	Cucumbers	313	26.00
Celery	198	87.75	Celery	97	66.00
Beets	134	80.60	Beets	67	80.00
Miscellaneous	11,648	....	Miscellaneous	3,725	....
Total	37,181	....	Total	25,714	....

Good truck lands are worth now from $50 to $200, or more, per acre, depending upon the condition of the soil and location and ease of transportation. Land immediately on the water or along a line of railroad is worth several times as much as similar land two or three miles away, on account of the difficulty and cost of transportation of the tender and bulky crop, and the damage done in hauling and handling. Much of the finest truck land of southern Maryland is lying out as a barren waste, and can be purchased for a merely nominal sum of from $1 to $5 per acre, on account of the present lack of transportation facilities. When this country is opened up and developed by railroad lines, which will foster this trucking and fruit interest, thousand of acres of the very finest truck and fruit lands will be available, and the southern portion of the State will be largely devoted to trucking and fruit growing.

The labor on these truck farms is scarce and wages are high. The work is both hard and exacting. Good laborers get from $12 to $20 per month with rations and a house. Skilled laborers get more. Women get from 50 cents to 75 cents per day, and men from 75 cents to $1. There is plenty of employment also for children. When the berries and vegetables ripen there is a great demand for pickers, and it is often difficult to get enough of them. Thousands of men, women and children find employment, being paid according to the quantity of work done, many of them earning quite large wages. It has demoralized house labor, for while a few years ago the wages of cooks and house girls in country homes rarely exceeded $4 or $5 per month it is now almost impossible to get them for even double this price, and even if they do take a place it is impossible to keep them from the field during the picking season, when they sometimes earn as much money in three or four days as they would get in a month's wages in the house.

According to the Census bulletin the cost of labor on the leading varieties of vegetables for the Baltimore and peninsula districts, ranges from \$10 to \$30 per acre. The cost of seeds ranges from 50 cents to \$10 per acre, according to the kind of vegetable. The fertilizers cost from \$10 to \$50 dollars per acre. The average net income is estimated at \$30 to \$100 per acre. This is far more profitable than either wheat or corn, besides the possibility of creating new or larger demands. Transportation facilities are constantly improving and enlarging; the use of refrigerator cars, holding as much as 4 tons of ice, has made it possible to transport vegetables to almost any distance reached by a single line of railroad in a fresh and healthy state; it is possible now to send the truck and fruit to Canada and to Cincinnati and the far West. These improved transportation facilities and the introduction of the canning industry for the preservation of fruits and vegetables for winter has greatly increased the value of these crops. Thirty years ago fresh berries sold in Baltimore for 1 cent per quart, they now sell for 5 or 10 cents per quart, and the early berries for 15 or 20 cents and even more. Peaches retailed at about 10 cents per peck, but now they average about 30 cents. Peas brought about 40 cents per bushel, but they now bring about \$1.20.

The trucking interest is thus assuming very large proportions and is a very important part of the agriculture of the State. It is growing rapidly and healthily and is likely to continue growing.

The following tables give the mechanical analyses of subsoils from a number of typical localities in southern Maryland:

MECHANICAL ANALYSES OF TRUCK SUBSOILS FROM SOUTHERN MARYLAND.

MARLEY NECK.

Diameter.	CONVENTIONAL NAMES.	Marley P. O. 471	Marley P. O. 472	1 mile north of Marley P. O. 591	Glenburnie. 469	Albert Hammond. 473	2 miles north of Marley P. O. 590
mm.							
2-1	Fine gravel	0.28	0 49	0.39	3 47	0.44	0.91
1-.5	Coarse sand	5.42	4 96	5.52	12.05	6.46	5.45
.5-.25	Medium sand	41.45	40.19	36.53	44.06	36.73	28.73
.25-.1	Fine sand	26.73	27.59	24.91	18.02	19.54	22 81
.1-.05	Very fine sand	12 46	12.10	11.79	9 59	10.28	13 44
.05-.01	Silt	7.22	7.74	9.89	5.73	13.42	14.77
.01-.005	Fine silt	2.21	2.23	4.51	1 37	5.61	4 29
.005-.0001	Clay	4.07	4 40	5.41	5.46	7.14	9.16
	Total	99.84	99.70	98.95	99.75	99.62	99.56
	Organic matter, water, loss	0.16	0 30	1.05	0.25	0 38	0.44

MARLEY NECK.—[*Continued.*]

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
471	Marley P. O.	4.07	583	1,809,000,000
472	"	4.40	615	1,955,000.000
591	1 mile north of Marley P. O.	5.41	796	2,458,000,000
469	Glenburnie	5.46	654	2.406.000.000
473	Albert Hammond	7.14	987	3,215 000,000
590	2 miles north of Marley P. O.	9.16	1,173	4,078.000,000

MECHANICAL ANALYSES OF TRUCK SUBSOILS FROM SOUTHERN MARYLAND.

NORTH MAGOTHY NECK.

Diameter.	CONVENTIONAL NAMES.	Armiger. 561	Armiger. 563	2 miles west of Armiger. 565	1 mile west of Armiger. 567	J. M. Cook. 577	2 miles north of Armiger. 589	J. M. Cook, loam. 575	Dr. E. Williams, loam. 571	Dr. E. Williams, loam. 569
mm.										
2–1	Fine gravel	0.74	0.39	2 12	2.46	1.52	2 33	1.26	0 34	0.87
1–.5	Coarse sand	7.13	7.04	8.81	13.32	4 50	26.08	8.91	2.97	5 82
.5–.25	Medium sand.	36.21	37.51	31.35	39.83	29.88	33 06	47.84	21.18	26.22
.25–.1	Fine sand	22.82	21.45	22.82	14 14	23 77	10.18	6 29	18.19	17.55
.1–.05	Very fine sand	14.15	13.45	16.76	9.34	10.36	4.71	6 29	17.17	16 34
.05–.01	Silt	9.26	10.72	10.19	10.17	17.16	13 14	15.08	21.05	16.33
.01–.005	Fine silt	4.68	3.72	2 08	3.29	3 83	3 58	5.76	9 57	7.45
.005–.0001	Clay	4.71	5.41	5.47	6 36	8 01	8.29	8.33	8.39	8.52
Total		99.70	99 69	99.50	98.91	99.03	102.39	99.92	98.86	99.10
Organic matter, water, loss		0.30	0.31	0.50	1.09	0 97	......	0 08	1.14	0.90

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
561	Armiger	4.71	727	2,137,000.000
563	"	5 41	769	2.427.000.000
565	2 miles west of Armiger	5 47	721	2,429,000.000
567	1 mile west of Armiger	6 36	824	2,856,000,000
577	J. M. Cook	8 01	1 060	3 596,000 000
589	2 miles north of Armiger	8 29	961	3 587,000 000
575	J. M. Cook, loam	8.33	1,102	3.676,000,000
571	Dr. E. Williams, loam	8 39	1.296	3 862.000 000
569	" "	8 52	1,204	3,869,000,000

MECHANICAL ANALYSES OF TRUCK SUBSOILS FROM SOUTHERN MARYLAND.

TICK NECK.

Diameter.	CONVENTIONAL NAMES.	Sandy land. 585	1½ miles northeast of Armiger's. 583	Loam. 587
mm.				
2-1	Fine gravel	0.45	0.28	6.06
1-.5	Coarse sand	10.33	6.09	22.09
.5-.25	Medium sand	46.29	39.48	29.87
.25-.1	Fine sand	20.15	23.00	9.82
.1-.05	Very fine sand	8.17	14 69	6.52
.05-.01	Silt	7.11	8.46	10.71
.01-.005	Fine Silt	2.29	2.48	3.86
.005-.0001	Clay	4.77	5.01	7.89
	Total	99.76	99.45	96.82
	Organic matter, water, loss	0 24	0.55	3.18

NO.	SOIL.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
585	Sandy land	4.77	629	2,121,000,000
583	1½ miles north of Armiger's	5.01	673	2,185,000,000
587	Loam	7.89	987	3 621.000.000

The soils in these tables having less than 6 per cent. of clay are typical early truck lands, those having 6 per cent. and over are rather heavy for the earliest truck. They produce more per acre but the crop does not bring such a good price. The heavier loam soils are much better adapted to small fruits and peaches than the very light soils.

These truck lands appear to be very uniform in texture and the slight differences in the percentage of clay are sharply defined in the agricultural value of the land—both as to the yield and the time of ripening of the crops. The samples given in the tables are all from the Columbia formation. There are no very large areas of the Eocene and Cretaceous lands uncovered, but these are rather heavier loams having from 8 to 15 per cent. of clay.

It has been stated that much of the truck land is lying out for lack of proper transportation facilities. Many of these lands have nearly the same texture as the bright tobacco lands of the South, and they would doubtless raise a very fine quality of tobacco for flue-curing. They are much lighter in texture than the regular southern Maryland tobacco lands, and would produce the finer textured leaf necessary for the fancy bright tobacco.

The following table gives the mechanical analyses of the subsoils of some bright tobacco lands from a number of typical localities in several states, sent to me by Dr. H. B. Battle, Director of the North Carolina Experiment Station:

MECHANICAL ANALYSES OF SUBSOILS OF BRIGHT TOBACCO LANDS.

Diameter.	CONVENTIONAL NAMES.	Haywood Co., North Carolina. 760	Lancaster Co., North Carolina 764	Beauford Co., North Carolina. 758	Buncombe Co., North Carolina. 761	Fayette Co., West Virginia. 756
mm.						
2-1	Fine gravel	3.72	6.41	0.00	7.30	0.00
1-.5	Coarse sand	10.57	17.48	0.89	7.11	0.24
.5-.25	Medium sand	13.89	29.66	9.18	9.11	21.23
.25-.1	Fine sand	15.52	17.18	43.54	10.55	20.49
.1-.05	Very fine sand	21.78	7.14	17.71	17.23	9.39
.05-.01	Silt	26.20	12.86	11.90	31.15	29.41
.01-.005	Fine silt	2.01	2.05	5.62	5.84	5.04
.005-.0001	Clay	3 60	4.05	7 63	8.77	8.80
	Total mineral matters	97 29	96.83	96.46	97.06	94.60
	Organic matter, water, loss	2.71	3.17	3.54	2.94	5.40

This table shows the texture of these bright tobacco lands to be almost identical with the truck and pine barrens, and as will be seen they are very much lighter in texture than the tobacco lands of southern Maryland.

3. **Tobacco, Wheat and Grass Lands of Southern Maryland,** *Chesapeake formation.* The strongest and most fertile soils of southern Maryland are in the diatomaceous horizon of the Chesapeake formation. This gives rise to three grades of soil—the lighter lands, having from 12 to 18 per cent of clay in the subsoils, form the finest tobacco lands of southern Maryland; where the subsoils contain from 18 to 25 per cent of clay they are well adapted to wheat; and where they contain from 25 to 35 per cent of clay they are sufficiently strong for good grass lands. There has been no attempt as yet to determine the limit of these different soils, nor is it known exactly what the distribution depends on, whether they represent distinct horizons in the Chesapeake formation or whether it is due merely to local causes acting since the sedimentary material was deposited.

The subsoil has a very characteristic yellow or reddish color. In many places the pure white diatomaceous earth can be seen underlying these lands at a depth of 2 or 3 feet, the yellow subsoil having been formed from the diatomaceous material by weathering. The yellow subsoil contains, as a rule, from 25 to 35 per cent of clay, and where this comes within 8 or 10 inches of the surface it makes the soils very retentive of moisture and well adapted to grass and wheat. Where this subsoil is more than 12 inches from the surface and is overlain by a lighter loam, the lands are rather too light for grass, but are still well adapted

to wheat. Where the loam is still lighter in texture, and has not over 18 per cent. of clay, it is too light for the profitable production of wheat, but is well adapted to tobacco.

Wheat and tobacco are commonly grown on the same land, in rotation periods of two or three years. The best lands for wheat, however, are the heaviest clay lands, while the finest quality of tobacco is produced on the lighter loams. The heavy clay lands produce a larger yield of tobacco per acre, but the plant has a coarse, thick leaf, which is sappy, cures green and will not take on color. The finest grade of tobacco is produced on the lighter loam soils, which are rather too light for the profitable production of wheat. Tobacco produces a small yield per acre on these soils, but the leaf has a fine texture, and in curing it takes a good color and brings a much better price in the market. As a rule, the lighter the soil in texture, the finer the quality of tobacco produced, and the higher price it will bring per pound, but the less yield there will be per acre; so that there is a limit to the profitable production of the very finest grades on the very lightest lands, as the price is not sufficient to cover the small yield per acre.

The following table gives the mechanical analyses of some tobacco soils from a number of localities in southern Maryland.

MECHANICAL ANALYSES OF SUBSOILS FROM SOUTHERN MARYLAND, RATHER LIGHT FOR WHEAT BUT THE FINEST TOBACCO LANDS.

Diameter.	CONVENTIONAL NAMES.	Chaneyville. 266	Marlboro. 258	North Keys. 164	Nottingham. 260	Chaneyville. 262	Marlboro. 162
mm.							
2-1	Gravel	1 40	1 53	0.58	0.48	0.00	0.09
1-.5	Coarse sand	2.94	5.67	0.50	3 05	0.07	0 13
.5-.25	Medium sand	11.23	13.25	1 35	12.08	1 56	0 58
.25-.1	Fine sand	13.42	8 39	10.65	12 09	13 51	4.90
.1-.05	Very fine sand	19.32	14.95	37.71	19.17	37 73	26 78
.05-.01	Silt	17.59	28.86	22.00	23.09	18.82	33.12
.01-.005	Fine silt	5.44	7 84	7 81	8.74	6.18	8.24
.005-.0001	Clay	10.72	14.55	16 02	18.42	18.79	21.81
	Total	97.06	95.04	96.72	97.12	96 67	95 65
	Organic matter, water, loss	2 94	4 96	3 28	2.88	3.33	4 33

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
266	Chaneyville	10.72	1,370	4,891,000.000
258	Upper Marlboro	14 55	1,902	6,786,000.000
164	North Keys	16.02	2,016	7,338,000.000
260	Nottingham	18.42	2,126	8,263,000,000
262	Chaneyville	18.79	2,197	8,530,000,000
162	Upper Marlboro	21.81	2,638	10 065,000,000

The finest quality of tobacco is produced on the soils shown to have the smallest amount of clay and the smallest number of grains per gram in this table. The heavier soils are much better for wheat and give a larger yield of tobacco per acre, but the quality of the tobacco is not so good, and it does not bring as good a market price. With the exception of 162 none of these soils would be considered very good wheat lands with the ordinary conditions of cultivation and manuring. They would be considered too light for the economical production of wheat. These lands are valued for wheat in proportion to the amount of clay contained in the subsoils, as shown in the table, but for tobacco the values are just reversed.

Tobacco has been a staple crop in Maryland from the earliest colonial days and has contributed more than any other factor to the growth, prosperity and commercial importance of the State. For nearly two hundred years Maryland and Virginia produced nearly all the tobacco consumed in Europe where its growth was prohibited by law, to provide a revenue through the importation from this country. The crop was very generally grown throughout the State, and for a time was made a legal tender for all debts and even used for the payment of salaries. Until the beginning of the late war it was very extensively grown on the Eastern Shore, but with the abolition of slavery it was given up there and owing to the scarcity of labor, the enormously increased production during the present century and the changing market demands the cultivation of tobacco is confined now almost exclusively to the southern Maryland counties.

The southern Maryland tobacco is strictly an export tobacco, being sent principally to France and Holland. It has a good yellow color and is very mild and suitable for pipe smoking. There is so much specialization in the tobacco market now that no one locality can hope as formerly to meet all the demands. The different types of fancy bright, heavy shipping, wrappers, fillers, etc., must each have a peculiar texture and color to meet the present market demands. The texture of the soil has more to do with this than any other factor and this alone practically determines where each of these different types can be successfully produced. There is no doubt that on account of the competition in our grade of tobacco in recent years. a series of very unfavorable seasons, the deterioration of the tobacco lands through less perfect methods of cultivation, manuring and handling, the crop has brought very low prices in recent years, and many farmers are giving up the cultivation of tobacco and are turning their attention to other crops and interests. Undoubtedly many of these conditions could be overcome and the quality of the crop improved, but the increased competition remains and it is a very general feeling that the type of tobacco should be changed so as to meet a higher market demand. There is no reason why this should not be done, especially as we have a great variety of soil formations in the State, but this can not be done simply by the introduction of seeds of other types of tobacco. The most important factor which determines the texture and color of the leaf is the texture of the soil and its relation to moisture and

heat. This, therefore, must govern any efforts in this direction and the kind of soil must largely determine the type of tobacco. It has already been pointed out that the texture of these lands is heavier than the fine, bright tobacco lands of the South, and that the leaf is heavier, thicker and coarser. The texture of the pine barrens and the truck lands are nearly the same and this type of tobacco could probably be successfully produced on some of those soils with proper treatment.

The following table shows the acreage and average yield of tobacco per acre in the last two Census years, and shows a marked reduction in the acreage of tobacco.

ACREAGE AND AVERAGE YIELD OF TOBACCO PER ACRE.—COMPILED FROM THE 10TH AND 11TH CENSUS.

	1879. Acres.	1889. Acres.	Percent. Dif. 1889.	1879. P'u'ds.	1889. P'u'ds.	Dif. Pounds.
STATE.	38,174	17,966	—52 9	683.2	687.7	—4.5
Southern Maryland.						
St. Mary's	5.528	2,904	—47.4	801 2	847.1	—45.9
Anne Arundel	6,271	3,750	—40.2	708.1	561.5	—146.6
Calvert	6,848	3.683	—46.2	567.5	483.7	—83.8
Charles	7,913	3,651	—53.8	650.2	551.8	—98.4
Prince George	9,637	5,322	—44.7	682.2	603.1	—79.1
Northern and Western Maryland.						
Baltimore	12	11	—8.3	800.1	1,240.0	+440.8
Cecil	43	1	—97.6	1,372.0	1,100.0	—272.9
Harford	52	154	+196.1	1,309.3	1,066 5	—242.8
Carroll	162	60	—62.9	846.7	916.6	+69.9
Howard	208	115	—44.7	667.9	797.2	+129.3
Frederick	429	162	—62.2	864.4	759 8	+104.6
Montgomery	1,053	460	—56.3	765.4	729.6	+35.8

NOTE.—No tobacco was returned from the Eastern Shore in 1889, except one acre from Wicomico, yielding fifty pounds. No tobacco was reported from Alleghany, Garrett and Washington counties in 1889.

The strongest and best wheat lands of southern Maryland appear to be confined to the diatomaceous horizon of the Chesapeake formation. The white diatomaceous earth can be found a few feet below the surface at all, or nearly all, the localities represented in the accompanying tables. The yellow clay of the wheat lands appears to have been formed by the weathering of this earth, as in a number of railroad cuts and river bluffs they are seen to merge together; and in all cases where air has had access to the diatomaceous earth through cracks and root holes, a thin layer of the yellow clay has been formed. Diatoms are still found in most of these samples of the subsoils of the wheat and tobacco lands.

There are two classes of wheat lands. On the ridges and high plateaus, where washing has not occurred to any extent, the lands are rather light and loamy, the loam being usually from two to four feet thick and overlying the heavier clay. These lands are better for corn than the heavier lands, but are not so good for wheat, and are too light in texture for grass. Where the underlying clay is exposed, as in the gently rolling lands, it makes a much stronger and better wheat soil and a good grass land. The accompanying table gives the mechanical analyses of the subsoils from a number of localities representing very fairly the wheat lands of southern Maryland.

MECHANICAL ANALYSES OF SUBSOILS OF WHEAT LANDS FROM SOUTHERN MARYLAND.

Diameter.	CONVENTIONAL NAMES.	Chaneyville, J. F. Talbott. 250	Davidsonville, P. H. Isreal. 248	Davidsonville, opposite church. 245	Plum Point. 180	Upper Marlboro. 155	½ mile west of Davidsonville. 246	Davidsonville. loam, T. S. Iglehart. 141	South River. 252	Popes Creek. 184
mm.										
2–1	Gravel	0.00	0.00	0.82	0 00	0 00	0.00	0.00	0 00	0.00
1–.5	Coarse sand	0.07	0.22	0.28	0.00	0.40	0.56	0.23	0.25	0.46
.5–.25	Medium sand	0.98	2.76	0 98	0.48	0.57	31.26	1.71	3.39	6.61
.25–.1	Fine sand	12.22	12.85	1.74	3.06	22.64	4.62	6.08	10 65	12 19
.1–.05	Very fine sand	29.58	47.13	52.74	50.32	30.55	30.70	30.82	29.05	9.15
.05–.01	Silt	23.19	12.89	16.91	14.19	13.98	26.16	20 92	22.45	30.89
.01–.005	Fine silt	10.13	4.07	3.35	6.78	4.08	9.44	11.21	6.56	13.22
.005–.0001	Clay	19.14	19.19	19.57	20.28	21.98	22.53	23.78	23.92	24.45
	Total	95.31	99.11	95.82	95.11	94.20	95 27	94.75	96.27	96.97
	Organic matter, water, loss	4.69	0.89	4.18	4.89	5.80	4.73	5.25	3.73	3 03

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
250	Chaneyville	19.14	2,453	8,918,000,000
248	Davidsonville, P. H. Isreal	19.19	2.097	8,452,000,000
245	Davidsonville	19.57	2,214	8,917,000,000
180	Plum Point	20.28	2,380	9,357,000,000
155	Upper Marlboro	21.98	2,493	10,228,000,000
246	½ mile west of Davidsonville	22 53	2,732	10,456,000,000
141	Davidsonville, lòam. T. S. Iglehart	23.78	2,853	11,161,000,000
252	South River	23,92	2,681	10,933,000.000
184	Popes Creek	24.45	2,847	11,202,000,000

These lands make fairly good wheat lands, but this is about the limit of profitable wheat production, for a soil having less than 20 per cent. of clay or approximately 9,000,000,000 grains per gram, is too light in texture and not sufficiently retentive of moisture for the economical production of wheat under the prevailing climatic conditions. This represents, however, merely the skeleton structure of the soil, and this could be so filled in and modified as to make it more retentive of moisture; but experience has shown that a soil lighter than this has not sufficient body to warrant the expense of converting it into a good wheat land. These soils are too heavy in texture for our Maryland tobacco, as the leaf is coarse and sappy and does not take on color. They are, however, too light in texture for grass.

The accompanying table gives the mechanical analyses of three soils from southern Maryland which are considered very strong wheat and grass lands.

MECHANICAL ANALYSES OF STRONG WHEAT AND GRASS LANDS FROM SOUTHERN MARYLAND.

Diameter.	CONVENTIONAL NAMES.	Davidsonville, clay, T. S. Iglehart. 142	Davidsonville, Jas. Iglehart. 247	Herring Bay. 179
mm.				
2-5	Fine gravel	0.00	0.00	0.00
1-.5	Coarse sand	0.00	0.27	0.00
.5-.25	Medium sand	0.29	0.64	0.50
.25-.1	Fine sand	2.43	3.20	3.50
.1-.05	Very fine sand	23.56	22.58	36.28
.05-.01	Silt	29 23	26.25	19.04
.01-.005	Fine silt	6.36	10 42	6.78
.005-.0001	Clay	32.45	32.40	32.42
	Total mineral matter	94 32	95.76	98.52
	Organic matter, water, loss	5.68	4.24	1.48

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
142	Davidsonville, clay, T. S. Iglehart	32.45	3,602	15,148,000,000
247	Davidsonville, Jas. Iglehart	32.40	3,537	14,903,000,000
179	Herring Bay	32.42	3,389	14,433,000,000

4. **Wheat and Corn Land,** *Columbia formation.* The fertile terraces bordering the Potomac and Patuxent rivers and tributaries, and the Columbia formation where it occurs at high levels in other parts of the State, have from 20 to 30 per cent. of clay in the subsoil, and on an average about 25 per cent. These lands are sufficiently retentive of moisture to make excellent wheat and corn lands. They are classed geologically with the Columbia terrace formation, but, as will be seen from the mechanical analyses and as shown from the agricultural value of the lands, they are very much stronger soils than those of the same formation on the bay shore, which form the early truck lands between Baltimore and Annapolis. The terraces have an elevation of from 20 to 60 feet above tide and are about half mile wide, with the Lafayette formation rising beyond this into the pine barrens of the higher lands further inland. The lands have good body and are capable of a very high state of cultivation, and many of them are maintained in a very good condition. Some of the land around Saint Mary's has been under cultivation for two hundred years without apparent deterioration, although there is nothing at all peculiar in the appearance of the land to indicate any unusual conditions. The soil is about 6 to 8 inches deep, but neither the soil nor subsoil appear to

have more organic matter than is usual in the lands of southern Maryland, nor do they appear different from the same class of lands elsewhere. They have been taken care of and have been very intelligently handled.

The following table gives the mechanical analyses of the subsoils from a number of localities:

MECHANICAL ANALYSES OF SUBSOILS OF WHEAT LAND.

RIVER TERRACE.

Diameter.	CONVENTIONAL NAMES.	Benedict. 199	St. Mary's. 201	St. Mary's. 203	Opposite St. Mary's. 205
mm.					
2-1	Fine gravel	0.38	0.44	2 01	0.41
1-.5	Coarse sand	2.72	1.05	5.24	0.42
.5-.25	Medium sand	11.64	2.67	1.75	1.64
.25-.1	Fine sand	7.23	5.03	2.17	3.45
.1-.05	Very fine sand	6.74	9.75	2.45	9.48
.05-.01	Silt	33.92	34.82	37.21	41.88
.01-.005	Fine silt	10.62	14.52	15.52	11.98
.005-.0001	Clay	23.45	25.03	29.27	26.24
	Total	96.70	93.91	95.62	95.50
	Organic matter, water, loss	3.30	6.69	4.38	4.50

NO.	CONVENTIONAL NAMES.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
199	Benedict	23.45	2,765	10,737,000,000
201	Saint Mary's.	25.03	2,889	11,936,000,000
205	Opposite Saint Mary's	26.24	3,188	12,205,000,000
203	Saint Mary's	29.27	3,509	13,578,000,000

5. **Grass, Wheat and Corn Lands,** *Gabbro, Gneiss and Phillite formations.* The soils derived from the disintegration of *gabbro*, forming the "red lands" of Cecil, Harford and Baltimore counties, of *gneiss* forming the "gray lands" and "mica lands" of Cecil, Harford, Baltimore, Carroll, Howard and Montgomery counties, and of *phillite*, forming the wheat and corn lands of Harford, Carroll, Frederick, Howard and Montgomery counties, are so similar in their texture and in their agricultural value that they may be grouped together. These lands have about 30 per cent of clay in the subsoil, and they are sufficiently retentive of moisture to make excellent wheat and corn lands and very fair grass lands. They are considered in every respect good average soils for general agriculture, well adapted to grass, wheat, corn, grazing and stock feeding, and to the raising of vegetables for canning.

The "red lands" of the gabbro formation are, as a rule, rather stronger than the others, and as a consequence they are usually somewhat harder to work and require more labor to keep them in a good state of tilth. In favorable seasons and with good treatment from 20 to 30 bushels of wheat can be produced on this land.

There is a much larger area of gneiss in the State than of gabbro. As a rule, the soil is sufficiently retentive of moisture to maintain good pasturage and it makes excellent wheat and corn lands. Some of the soils are rather too light for profitable wheat production and these are admirably adapted to truck and vegetables, but the crops ripen so late that they come into competition with crops from other parts of the State and they do not bring as good prices as crops from the light truck lands in southern Maryland and the Eastern Shore. Large crops of tomatoes and corn, however, are raised on the lighter soils of the gneiss formation for canning, and in some localities this interest has replaced the cultivation of wheat to a large extent.

The phillite formation covers the northern part of Harford, Carroll, Howard and Montgomery, and the eastern part of Frederick counties. It has, as a rule, about the same texture and the same agricultural value for grass, wheat and corn as the two formations just described. Tobacco is grown to a limited extent on newly cleared phillite lands, but it is a very much larger and heavier leaf and has altogether a different texture from that grown on the lighter soils of southern Maryland.

The following table gives the mechanical analyses of some of the gneiss and gabbro lands:

MECHANICAL ANALYSES OF GABBRO AND GNEISS SUBSOILS.

Diameter.	CONVENTIONAL NAMES.	Gabbro, Pimlico. 133	Gabbro, Havre-de-Grace. 1034*	Gneiss, Glenville. 1045
mm.				
2–1	Fine gravel	0.00	0.00	0.19
1–.5	Coarse sand	1.50	0.26	1.80
.5–.25	Medium sand	3.49	0.18	3.12
.25–.1	Fine sand	6.24	0.66	6.96
.1–.05	Very fine sand	11.74	6.73	8.76
.05–.01	Silt	32.60	47.32	34.92
.01–.005	Fine silt	10.77	10.04	12.14
.005–.0001	Clay	26.62	34.90	28.82
	Total mineral matter	92.96	94.44	96.71
	Organic matter, water. loss	7.04	5.56	3.29

MECHANICAL ANALYSES OF GABBRO AND GNEISS SUBSOILS.—[*Continued.*]

NO.	SOIL.	Clay. Per cent.	Surface area. Square centimeter.	Approximate number of grains per gram.
133	Gabbro, Pimlico	26.62	3,207	12,677,000,000
1034	Gabbro, Havre-de-Grace	34 90	4,004	16,265,000 000
1045	Gneiss, Glenville	28.82	3,017	13,140,000,000

*This is from field adjoining where 1025, analyzed by Prof. Packard, was obtained.

6. **Grass and Wheat Lands**, *Triassic and Catskill Red Sandstone formations*. These subsoils contain about 35 per cent. of clay, and have about equal agricultural value. The Triassic red sandstone is locally known as the "red lands" of Carroll and Frederick counties. It is sufficiently retentive of moisture to make admirable grass and wheat lands. It lies next to the Trenton limestone, which is the strongest type of grass land in the State. In favorable seasons and with good treatment these Triassic red sandstone soils will make about as much wheat per acre as the adjoining limestone lands, but the crop is never as safe nor as certain for the soil is not as heavy in texture as the limestone land; it is not as retentive of moisture and the crop is much more effected by unfavorable seasons and by extremes of wet and dry weather. These lands, like the limestone lands, are greatly benefitted by an application of lime. They are easier to work than the limestone lands, but, on the other hand, they cannot stand such hard farming as the heavier limestone soils can. The Catskill red sandstone forms some very fertile valleys in Garrett and Alleghany counties. They are very strong clay lands, very retentive of moisture and are admirably adapted to wheat and grass.

The following table gives the mechanical analyses of samples from each of these formations.

MECHANICAL ANALYSES OF TRIASSIC AND CATSKILL RED SANDSTONES.

Diameter.	CONVENTIONAL NAMES.	Triassic, Near Frederick. 282	Triassic, Mechanicstown. 949	Catskill, Mount Savage. 238	Catskill, Buck Valley. 897
mm.					
2–1	Fine gravel	0.00	0.00	0.00	0.00
1–.5	Coarse sand	0.23	0.00	0.11	0.78
.5–.25	Medium sand	1.29	0.02	0.42	5.62
.25–.1	Fine sand	4.03	0.12	2.63	8.36
.1–.05	Very fine sand	11.57	4.32	11.35	18.24
.05–.01	Silt	38.97	35.73	40.23	22.86
.01–.005	Fine silt	8.84	16.73	10.90	6.48
.005–.0001	Clay	32.70	38.63	33.32	37.24
	Total mineral matter	97.63	95.55	98.96	99.59
	Organic matter, water, loss	2.37	4.45	1.04	0.41

MECHANICAL ANALYSES OF TRIASSIC AND CATSKILL RED SANDSTONE.—[*Continued*]

NO.	SOIL.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
282	Triassic red sandstone, Frederick	32.70	3,593	14,736,000,000
949	Triassic red sandstone, Mechanicstown	38.63	4,415	17,889,000.000
238	Catskill, Mt. Savage	33.32	3,669	14 839,000.000
897	Catskill, Buck Valley	37.24	3,756	16,387,000,000

7. Grass and Wheat Land, *Trenton Limestone* This is the strongest and finest type of grass and wheat land in the State. The subsoil contains from 40 to 50 per cent. of clay, which makes it very retentive of moisture. There is, on an average, about 45 per cent. of clay, and approximately 22,000,000,000 grains of sand and clay in one gram of this subsoil, which divides up the empty space very much and the rainfall has to pass down through the innumerable little passages between these grains. The grains of sand and clay in one cubic foot of this subsoil have no less than 158,000 square feet of surface for water to act on in dissolving food material and for roots to feed on. In a cubic foot of this subsoil there is, therefore, no less than 3½ acres of surface exposed to the action of the water and roots. This enormous extent of surface makes it possible, of course, for the plants to extract a considerable amount of food material from the soil. The large number of grains in this subsoil makes it a very fine and close-textured, stiff clay, which is very retentive of moisture although it is also well drained. Good crops of grass and wheat are assured in all ordinary seasons, and with good treatment from 30 to 40 bushels of wheat per acre can be produced on this land.

These soils are the impurities originally contained in the limestone rock, which have been left behind as the lime has been dissolved and carried off by water. There is, of course, a very small amount of impurities in the limestone rock, and after the large amount of lime has been dissolved the impurities settle, and, as a consequence, the limestone soils are nearly always valley lands with ridges on either side formed of rocks which were much less soluble than the limestone. Another important fact is that the lime is in the form of a carbonate which is readily soluble in water containing carbonic acid gas in solution, whereas the lime in most ordinary soils is in the form of sulphate or silicate, either of which is much less soluble in water than the carbonate, so it happens that, strange as it may seem, these limestone soils are frequently deficient in lime, and there is no class of soils in the State which is more benefitted by an application of lime than these same soils resulting from the disintegration of the limestone rocks. It is very frequently the practice in these limestone regions to get out the rock and burn it in kilns and spread it directly on the land from which it came. It will be seen from the chemical analysis of 933 that there is little lime in these soils.

There are two large areas of this Trenton limestone in the State forming the fertile lands of the Frederick Valley and of the still larger valley around Hagerstown, a continuation of the famous Shenandoah Valley of Virginia. There are two grades of soil; along the rivers the strong red clay, containing from 45 to 55 per cent. of clay, is exposed, forming the very strongest type of grass land in the State; along the ridges and at high levels a lighter loam has accumulated. These lighter soils are not so valuable for grass, and they are usually devoted to wheat and corn. The lighter soils are given up, therefore, mostly to wheat and corn, while the heavier soils are more valuable for grass. Where the stiff clay comes to the surface the lands make the finest grass lands, where this is covered with 8 to 10 inches of a heavy loam it still makes fine grass and even better wheat lands than the heaviest soils. Where the red clay is 10 inches, or more, from the surface corn and wheat are the principal crops. The market value of these lands is largely governed by the texture of the soil and the depth of this stiff red clay from the surface.

I have a great many samples of this Trenton limestone soil from both the Frederick and Hagerstown Valleys, collected with special reference to this distribution, but they have not yet been examined.

The following table gives the mechanical analyses of the subsoils from a number of localities in the Trenton limestone formation.

MECHANICAL ANALYSES OF TRENTON LIMESTONE SUBSOILS.

Diameter.	CONVENTIONAL NAMES.	Near Union Bridge.	Frederick Valley.	Harper's Ferry.	4 miles south Hagerstown.	Frederick Valley.
		....	173	231	933	174
mm.						
2–1	Fine gravel	0.85	0.54	0.60	0.17	0.00
1–.5	Coarse sand	0.56	0.32	1 61	0.00	0.00
.5–.25	Medium sand	1 19	0 72	2.26	0.15	0 18
.25–.1	Fine sand	1 38	0 62	1 71	0 25	0.26
.1–.05	Very fine sand	9.36	4.03	11.37	2.34	2.39
.05–01	Silt	26.17	36 02	19.30	19.04	27.60
.01–.005	Fine silt	15 71	14.99	13.79	20.88	10.74
.005–.0001	Clay	39.09	41.24	43.14	51.77	53.02
	Total mineral matters	94.31	98 48	93.78	94 60	94.19
	Organic matter, water, loss	5.69	1.52	6.22	5.40	5 81

NO.	LOCALITY.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
......	Near Union Bridge	39.09	4,519	18,302.000,000
173	Frederick Valley	41.24	4,464	18,480,000,000
231	Harper's Ferry	43.14	4,702	20,252,000,000
933	4 miles south Hagerstown	51.77	5,686	24,243,000,000
174	Frederick Valley	53.02	5,573	24,652,000,000

This description of the principal soils of the State, exclusive of those on the Eastern Shore, covers all of the most important agricultural regions, with the exception of the famous Middletown Valley which has not yet been studied as the geology of that section has only recently been worked out. The remaining soils on the list which have been given have either very little agricultural value or occur in very limited areas in the State. There are two or three narrow belts of very fertile soils derived from the Helderberg limestone, which have a value only a little, if any, inferior to the Trenton limestone, and these have about the same texture, although, as a rule, they contain rather less clay than the Trenton limestone. The Cambrian sandstone has come into considerable prominence of late years as the centre of the mountain peach industry. These soils have been sampled very thoroughly, but the samples have not yet been examined.

Of the remaining soil formations on the list the Potomac is of peculiar interest, as it has considerable extent in one of the most traveled portions of the State, from Washington through Baltimore to the Delaware line. These clay hills along the Baltimore and Ohio and Baltimore and Potomac railroads give travellers a very poor idea of the agricultural features of the State.

It has been shown that there is no apparent reason in the chemical composition for the lack of fertility of these clay hills, unless it be from the low percentage of lime. There is no apparent reason for this either from the mechanical analysis of the soils for they have no more real "clay" than the very fertile Helderberg and Trenton limestone lands. The clay, however, is differently arranged, and these clays have the effect of having been puddled as they are almost impervious to water. The movement of water through them is so extremely slow that plants suffer for their needed water supply as they do in light sandy soils. Indeed the vegetation on these clay hills is somewhat similar to that of the pine barrens. It should be quite possible to change the arrangement of these soil grains through judicious cultivation, cropping and manuring, and improve the texture of the land and make it as productive as the limestone soils.

The following table gives the mechanical analyses of some samples of the Potomac clays from a number of localities.

MECHANICAL ANALYSES OF SUBSOILS OF POTOMAC CLAYS FROM NEAR BALTIMORE.

Diameter.	CONVENTIONAL NAMES.	Red clay, tile. 304	Red clay, puddling. 305	Near Marley. 592	Blue clay, stoneware. 303
mm.					
2-1	Fine gravel	0.00	0.31	0.00	0.00
1-.5	Coarse sand	0.00	0.82	0.00	0 00
.5-.25	Medium sand	0.50	2 69	0 00	0.29
.25-.1	Fine sand	2.63	3 23	0.07	1.27
.1-.05	Very fine sand	9.62	8 89	0.12	8.93
.05-.01	Silt	25.13	26 17	37.94	20 16
.01-.005	Fine silt	13.44	11.18	12 15	16.72
.005-.0001	Clay	42.34	42.36	44.51	50.02
	Total mineral matter	93.76	95 65	94.79	97.39
	Organic matter, water. loss	6.24	4 35	5.21	2 61

NO.	SOIL.	Clay. Per cent.	Surface area. Square centimeters.	Approximate number of grains per gram.
304	Red clay, tile	42.34	4,737	20,072,000,000
305	Red clay, puddling	42.36	4,566	19,447,000.000
592	Red clay, near Marley.	44.51	4,600	19,800,000,000
303	Blue clay, stoneware	50 02	4.905	22,639,000.000

THE ARRANGEMENT OF THE GRAINS OF SAND AND CLAY IN THE MARYLAND SOILS.

The relation of a soil to moisture and the amount of moisture it can maintain for a plant is dependent not only upon the percentage of clay and the number of grains per gram, but also upon how these grains are arranged and upon the amount and condition of the organic matter. This latter may be neglected for the time. The number of grains per gram show how much the space within the soil has been divided up, but it must be known how these grains are arranged to know how much resistance will be offered by the soil to the rain which falls.

This work requires observations on the soil in its natural condition in the field. The method is based upon the time required for a measured quantity of air or water to flow through a given weight and depth of soil under a constant or known pressure. This work was planned for the present year, but it had to be given up, and the investigations were carried on on the air-dried laboratory samples. The results were not altogether satisfactory and they are not of enough general interest to give here. They gave an indication of the relative arrangement of the grains in the different soils, but this will have to be confirmed by investigations in the field.

EFFECT OF FERTILIZERS ON THE SOIL.

It is very generally believed that the "chief use of fertilizers is to supply food which plants need and the soil fails to furnish." It is known that fertilizers have an important effect on the texture of soils and their relation to water, although this has, in most cases, been considered an incidental and relatively unimportant matter. It follows, however, from what has been said, that if the relation of our typical soils to the development and production of crops, if, for instance, the difference of yield of wheat per acre under similar treatment, of 5 bushels on the truck lands and 40 bushels on the limestone, is due to the texture of the soils and their relation to moisture and heat, then these must be the controlling factors in the relation of these soils to crops, and no mere addition of plant food will have any material effect upon the crop unless it changes these physical conditions in the soil. Such substances as lime, phosphates, potash salts and nitrogenous matters undoubtedly have very important effects upon the arrangement of the soil grains and upon the amount and condition of the organic matter, and we have in these common fertilizers very powerful and potent means for maintaining or changing these physical conditions in the soil. Our laboratory experiments show that it is perfectly possible by rearranging the soil grains by the action of these commercial fertilizers to make the light truck lands as impervious to water as the limestone soils. It would, of course be a matter of great expense to change these conditions so radically in the soil of the field, but the principles can be used and the soils made more retentive of moisture.

Considerable work has been done in the laboratory on the effect of fertilizers on the texture of these soils, and Mr. Bliss is studying the forces which act to move the grains and cause a rearrangement. It was expected to make some experiments on these soils in their natural position in the fields to study the effect of fertilizers on them, and experiments were actually started last summer on several of the soil formations in the State, but the work had to be abandoned.

THE MARKETS FOR THE CROPS.

We thus have in Maryland a variety of soils adapted to a great variety of crops and of agricultural interests. What is equally important, we also have ready markets and ever extending markets for these different products and interests.

Wheat can be grown in the West and transported at such a low cost that we can no longer afford to give up our lands to this crop, except such as will bring a large yield per acre. The heavier grass and wheat lands of the State will always be adapted to wheat, for yields of 30 and 40 bushels per acre can be obtained from these lands by good treatment. But even on these lands other more profitable interests, such as the fattening of cattle, canning of vegetables and the diary interests, are growing. The Baltimore, Washington and Philadelphia markets consume enormous

quantities of milk and butter, and the improved transportation facilities and the introduction of the creamery methods have opened up a wide territory for this dairy business.

The production of early vegetables and fruits on the light sandy soils of Southern and Western Maryland, which formerly had little or no agricultural value, has grown enormously as the markets have been widely extended by the improved transportation facilities. Refrigerator cars, carrying four tons of ice, will carry vegetables, fruits or berries to Canada or to Cincinnati and the far West in a perfect state of freshness, and such car-loads are shipped through by the producers themselves without going through the hands of middlemen and agents in Baltimore. The canning of vegetables and fruits for winter use has also largely increased the demand, and in spite of the large increase in production the average market price of these crops is from four to ten times as much as it was 25 or 30 years ago.

SUMMARY.

1. There are a large number of soil formations in Maryland, giving about 12 or 15 distinct types of soil.

2. These soil types have very different and very characteristic agricultural values.

3. The difference in the chemical composition of these soils will not account for the difference in their agricultural values.

4. Difference in climatic conditions and changing seasons have far more effect on the development and yield of crops than fertilizers have.

5. The texture of these soil types are very different, and there is a greater difference between the conditions of moisture and heat maintained by these soils than ordinarily experienced in changing seasons or in widely separated localities.

6. The development and yield of crops on these soil types, and therefore their relative agricultural value, is dependent upon these conditions of moisture and heat which they maintain for the crops.

7. The relation of these soils to moisture and heat is largely dependent upon the arrangement of the soil grains and upon the amount and condition of the organic matter in the soil. In our ordinary fertilizing materials we have very powerful and potent means of maintaining or of changing these conditions, and it is to this rather than to the amount of plant food they supply that the principal effect of fertilizers is due.

8. This does not detract in any way from the value or importance of our commercial fertilizers, but only explains their action on a new basis from that generally accepted.